



THE BRITISH SOLOMON ISLANDS GEOLOGICAL RECORD 1957 - 1958

Reports on Investigations into the Geology and Mineral
Resources of the Protectorate

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NOTE

The Reports are available only in this volume. They are not available separately.
This is the third publication by the Geological Survey since its inception in 1950.

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1957-1958

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THE SOLOMON ISLANDS GEOLOGICAL SURVEY STAFF, 1957-58

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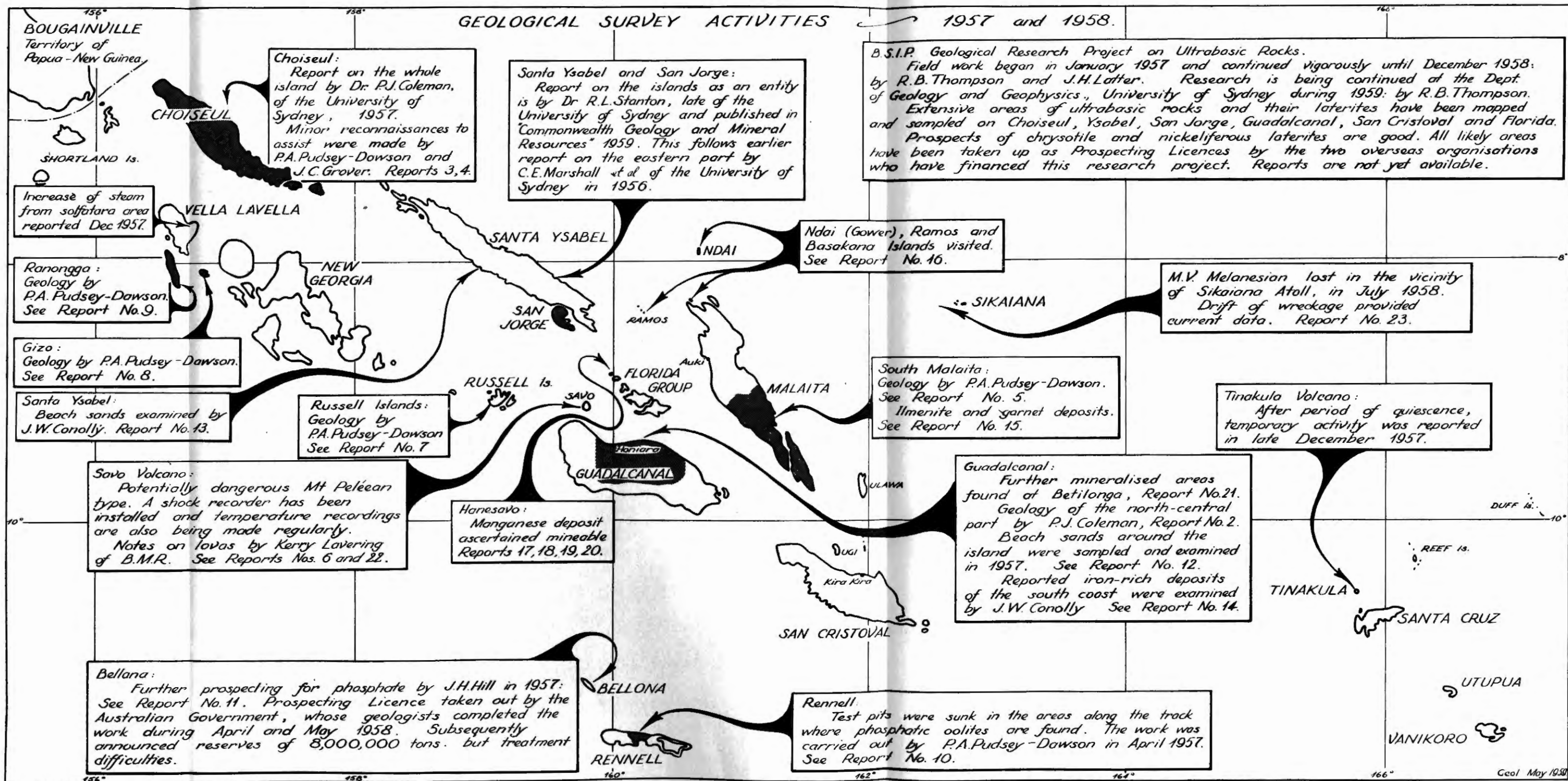


FIG. 1.—Map of Solomons showing areas of activities during 1957-58

REPORT No. 1

DEVELOPMENTS IN THE SOLOMONS DURING 1957 AND 1958

By J. C. GROVER

In the Solomons we are still in the primary phase of fundamental geological exploration — reconnaissance surveys which have been under way since 1950 aimed at rapid regional mapping.

The year 1957 did not see the resumption of prospecting activity on Gold Ridge : Clutha Development Ltd. withdrew at the onset of the wet season in early December, 1956. However, a research project was begun, covering the intrusive basic and ultrabasic rocks of the Protectorate, with two geologists* financed entirely by two private overseas organisations, working in close co-operation with the Geological Survey. Dr. Coleman, from the University of Sydney, assisted at times by Messrs. Thompson and Pudsey-Dawson, mapped Choiseul Island, in the Western Solomons, a major achievement in the face of extraordinary difficulties. The southern half of Malaita was mapped, as were the Russells, and the smaller islands of Gizo and Ranongga.

Dr. Dixey, the Director of Overseas Geological Surveys, visited the Department in June.

The Chief Geologist was absent overseas for most of 1957, and Mr. Pudsey-Dawson was responsible for the organisation of the increased activity during that year.

The activity continued at increased tempo during 1958. The two outside organisations continued to support the survey in the field, and economic discoveries have resulted ; two other organisations have followed up our work and concluded successfully the detailed exploration of two mineral deposits of economic significance. Four geologists have been operating for most of the year, with another for six months ; five others and a geophysicist, all visitors, were operating for shorter periods on special undertakings. In addition, the Royal Navy Survey Vessel, H.M.S. *Cook*, spent about four months in the area on hydrographic, magnetometric and bathymetric surveys, which will be of value.

For the first time since the establishment of the Survey (in 1950) all personnel were engaged in areas of economic interest during 1958. The following are the immediate results of importance from this work :

- Bellona phosphate reserves were shown to be substantial, though not high grade.
- Hanesavo Manganese Deposit was shown to be mineable.
- Garnierite† was discovered for the first time—on Santa Ysabel.

* Messrs. R. B. M. Thompson, M.A.(Cantab) and J. H. Latter, B.A.(Cantab).

† Hydrated nickel and magnesium silicates, an important ore of nickel.

- Chrysotile asbestos bearing areas were found and mapped on San Jorge.
- Further mineral-bearing areas were found in the Betilonga area of the Guadalcanal Mountains.

Four areas have been made the subject of Prospecting Licences and one of these is under further application for a Mining Lease.

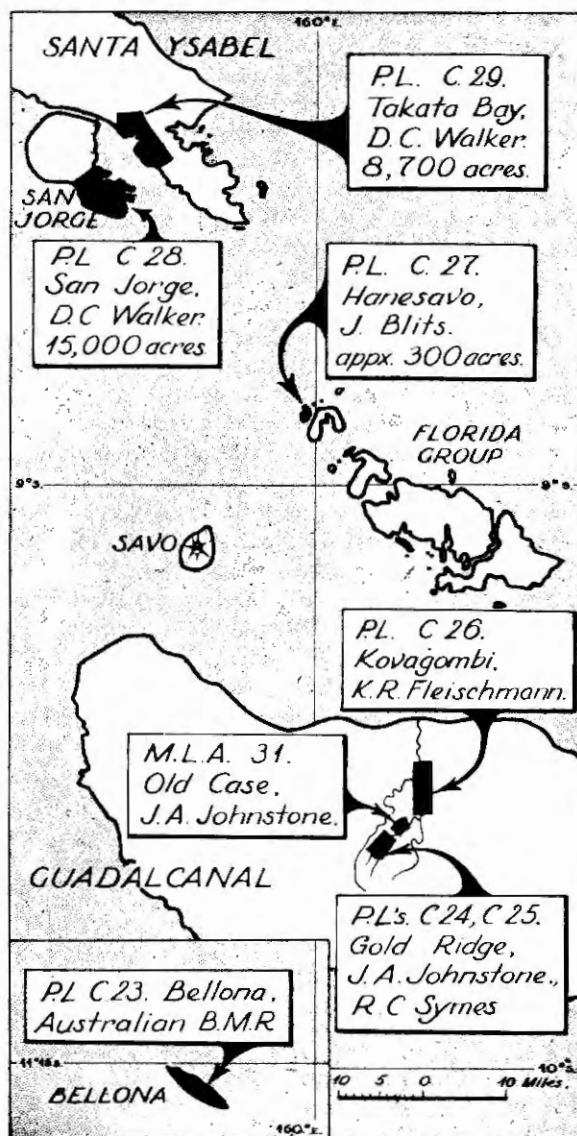


FIG. 2.—Areas held by mining organisations at the end of 1958

The Department's investigations on Bellona were completed in November 1957, with the sampling of the phosphates of iron and alumina which constitute the bulk of the material in the fertile central valley. The Australian Bureau of Mineral Resources had recently been granted a Prospecting Licence covering Bellona, and arranged examination and assay of these samples. Three Bureau geologists*, and a party of 14 arrived on April 21st; two geologists undertook the final boring programme on Bellona, and one made a reconnaissance of smaller islands in the east of the Protectorate. The team left the Protectorate on May 27th. Subsequently it was announced that there were phosphate reserves of the order of 8,000,000 tons on Bellona.

Attention was again given to Hanesavo Island manganese deposit. Since the Survey's reconnaissance in 1951, successive prospecting licence holders had failed to undertake the required further development work. One survey geologist and party spent six weeks in January and February trenching and tunnelling, confirming the presence of more manganese. Another geologist and party continued the work for another fortnight in March and discovered a sulphide body, its highest point being 10 ft. below the surface: there had been no outcrops or indications of it on the surface (see Report No. 19). In April a Prospecting Licence was issued, so the department did not carry on with sampling: this was done by a visiting geologist† between May 19th and June 6th. As well as sampling the available trenches he did further trenching and pitting on this occasion. Also in June a Royal Navy shore-party made a hydrographic survey of Hanesavo harbour—which appears suitable for ocean-going ships. Subsequently, in September, news was received that the assays were favourable, and a Mining Lease was applied for.

The Royal Navy Hydrographic Survey Vessel, H.M.S. *Cook*, arrived on March 31st, and remained in the region until June 14th. Funds had been arranged‡ to permit Mr. Gray, geophysicist from the Imperial College of Science and Technology, to fly to New Zealand to join and equip the ship with a towed proton magnetometer. Thus, as well as bathymetric data, the ship was able simultaneously to record magnetic data during travels in the Solomons, New Guinea and Fiji waters. The work is to be the subject of a separate research paper by Mr. Gray at a later date.

In addition to the ship-towed unit, Mr. Gray's newly-developed light-weight portable proton resonance magnetometer (weight 22 lb. all up) was made available to the department. Grids were laid out on Hanesavo Manganese Deposit, and on Eastern San Jorge's laterite-capped ultrabasic hills. The ease of operation and the surprising consistency of the results indicate that future magnetic

surveys will be considerably expedited by the use of this instrument in rough country such as the Solomons. Instead of 15 stations an hour by ordinary magnetometer, we were able to do 60 stations an hour with the new instrument—using Solomon Islander staff after only an hour's instruction (see Report No. 17).

The eastern end of San Jorge has received more detailed attention this year than has any other part of the Protectorate. On one occasion five geologists, one geophysicist and all other field personnel were concentrated there. Chrysotile-bearing areas and nickelliferous laterites have been mapped and sampled by scout pitting and boring, and a magnetic survey was made using the new portable proton magnetometer. Garnierite was found on Santa Ysabel in November. All this was done as part of the "BSIP Geological Research Project". Full details of the research done are, however, not being published for some time, as they will first be the subject of a thesis§ covering three years' study. This work should be a major contribution to the knowledge and understanding of ultrabasic rocks, as it involves all the known occurrences on the major islands of Choiseul, Ysabel, San Jorge, Florida, Guadalcanal and San Cristoval—over a distance of 400 miles and under many different and interesting conditions of emplacement. Here and there it will be supported by magnetic and bathymetric data. It is unfortunate that the study cannot be supported also at this stage by gravity data obtained by submarine.

The visit on May 28th of the Oceanographic Vessel *Orsom III*, of the Institut Français d'Océanie, Noumea, was of interest from the point of view of personal contact with scientists of the French Pacific Territories and because it was possible to see the equipment and laboratory on board. Further visits to the Protectorate are planned for future years.

The loss of the M.V. *Melanesian*, and the total wreck of M.V. *Betua* at the same time, aggravated the shipping position, and it has been necessary since for the survey to modify its plans with its small ship *Noula*.

Savo Volcano was visited by the High Commissioner on January 21st. An access track had been prepared by the Geological Survey via the hot stream inland from the south coast to Vogala and the central crater: thermal areas were seen, and a spine extremity of the central dome climbed (about 150 ft. from the south-east side). The island rumbled impressively about three times every hour—which was a new development. A shock recorder was installed on the island's east coast in March, mounted on a concrete block, and sheltered in a timber building. Islanders were instructed in the daily changing of the smoked papers, and regular records have been obtained since. The recorder will detect shocks which can be felt by persons—it is not sensitive enough to give early warning of an impending *nuée ardente* eruption. Recommendations for the establishment of a sensitive seismological station at Honiara were subsequently approved by the Secretary of State.

For the last five months of the year detailed surveys

* Messrs. W. White, Senior Geologist, O. Warin and C. Jensen, with two Australian field assistants and 12 Trobriand Islanders on board M.V. *Kokoda*.

† Dr. C. Phipps, Dept. of Geology and Geophysics, University of Sydney. (See Report No. 20.)

‡ Colonial Development and Welfare Scheme.

§ By Mr. Thompson.

have been made in the Betilonga Valley and surrounding areas in the Guadalcanal Mountains south of Honiara. Much trenching and pitting was undertaken, and disappointments and difficulties have been many. However, two more substantial bodies have been discovered in the surrounding area, one of which looks more promising than the other. Indications of copper sulphides, talc, magnetite, barytes, and fine gold have been noted, and the regional knowledge has been extended by mapping the rough country southwards towards the backbone

ranges, and to the westward in the tributaries of the Betikama-Lunga River, where further mineralisation was found.

Further work was done on East Malaita ilmenite and garnet gravels. Further exploration was undertaken also on South Malaita.

Efficiency has suffered because of lack of space and facilities to handle such a number of geologists, and the overall increase in activity. This state of affairs is to be remedied in the near future.

REPORT No. 2

NORTH-CENTRAL GUADALCANAL.—AN INTERIM GEOLOGICAL REPORT

By P. J. COLEMAN

(Dept. of Geology and Geophysics, University of Sydney)

The area considered in this report is an eastern extension of an area described in a previous report and now published as part of the results of the 1950-51 University of Sydney Department of Geology and Geophysics Expedition to the British Solomon Islands (*Bulletin of Colonial Geology and Mineral Resources*, Vol. 6, No. 3, 1957). The area is bounded to the west by the Lunga River and its north-flowing main tributaries, to the east by the Kombito River, and to the south by the line of the Central Highlands, including the Kavo Range. Geological traverses were made over native tracks and along most of the rivers. They were tied into field sheets

Grover respectively. Later discussion with these colleagues also clarified many doubtful points. Finally, the results obtained by laboratory study of the specimens collected and by interpretation of the air photographs have been incorporated in the report.

Stratigraphy

The rocks of Central Guadalcanal can be considered as made up of four main categories: the older igneous basement rocks, the middle Tertiary sediments, the uppermost Tertiary-Quaternary sediments, and the sub-recent alluvial beds grading into present-day shore-line



PLATE I

Dr. Coleman and bearers at Betilonga Village in the headwaters of the Tenaru River, Guadalcanal

compiled from air photographs; these provided a complete coverage of the area.

The only serious work carried out previously in the area was done by J. C. Grover, Chief Geologist, British Solomon Islands Geological Survey, who surveyed the gold-bearing rocks in the Betilonga, Gold Ridge and Sutakiki Valley areas. His results are published in Memoir No. 1 of that Survey.

This report aims to give the regional geological picture of the area. It is based on the previous work of Mr. Grover, on the results of a season's fieldwork by myself, during which work was hindered by heavy rain with consequent flooding of the rivers, and by two later traverses carried out by Messrs. Pudsey-Dawson and

sediments. They are given the following provisional names: the Basement Complex, the Metapona Beds, the Mount Austen Beds, and the Nalimbu Alluvials.

The Basement Complex

The rocks making up the "core" of the island, upon which the overlying sediments rest unconformably, are exposed mainly in the deeper valleys to the south of the area and in fault-bounded blocks appearing as windows in the surrounding sediments in central parts of the area. The term "Basement Complex" is a dump-box one, covering a variety of rock types. The oldest are greenish shattered and sheared altered lavas with which occur rarer sediments—very fine-grained indurated silts and

cherts are the most common—the whole being heavily chloritised and epidotised. In some localities the shearing is so pronounced as to give a semi-schistose appearance to the rock, but few true schists have been found as yet. The most common lava types are dolorites and basalts which have been deuterically altered, with veins of epidote and relics of augite converted to tremolite. None of the available specimens show more than this low grade of metamorphism. These “green rocks” seem to make up the basement in the eastern and southern part of the area. Towards the west, and in the isolated blocks mentioned, the basement rocks so far found are made up of a dioritic type together with overlying or intrusive andesitic lavas. The diorites are often finer-grained than is usual, with a felsitic groundmass, abundant labradorite, and with strongly pleochroic green to red-brown hornblende. Others are sub-granitoid, with a minor percentage of quartz and biotite. All specimens show strain effects. The feldspars are usually saussuritized. Magnetite is the most common accessory mineral. Some specimens are very heavily mineralised with pyrite and marcasite, in part certainly epigenetic. The lavas can all be classed as andesites although there is considerable variation in composition and structure.

By and large, the least altered of them show variation in texture rather than in composition.

A common variety has a pilotaxitic groundmass, very much altered from saussuritisation of the feldspars, occasionally with minute granules of augite. The phenocrysts consist of large tabular crystals of plagioclase, usually labradorite but also andesine, strongly zoned and with albite and carlsbad twinning. Dust inclusions defining the zonation are usual. The hornblende is a brown pleochroic variety, commonly twinned. With it there may be a few crystals of dark-brown “iron” hornblende. Chlorite-with-montmorillonite is a common accessory together with granular epidote, hypersthene, and iron oxides.

Another variety is a glassy andesite with large laths of labradorite sometimes ophitically surrounded by augite, the groundmass made up of tiny shards of feldspar and abundant glassy material, the latter showing spherical crystallites and perlitic fissures; iron oxide and analcite are common accessory minerals.

Propylitized andesite is very common in which the feldspar is replaced by granulitic epidote, the relic form of the feldspar being retained, the hornblende greatly altered with resorption boundaries containing dusty iron oxide, and with abundant chlorite. The groundmass is changed to a cloudy aggregate in which little of the original structure can be determined.

In the western part of the area, notably in the south of the middle Tina River, the andesites are overlain by tuffaceous andesitic agglomerate. The larger rock fragments are andesite, the matrix consists of small andesite pieces and worn crystals of feldspar, amphibole and pyroxene. The rock fragments can usually be determined as andesite, but often both matrix and fragments are reduced to a cloudy mass of altered feldspar, abundant iron oxides, clusters of epidote crystals the whole

intensely chloritised with abundant epidote and zeolite veins.

Most exposures of rocks of the Basement Complex are mineralised. This takes the form of secondary pyritisation, the pyrite often accompanied by marcasite and/or chalcopyrite. The pyrite is by far the most abundant of these sulphides. In some localities it occurs in veins up to one-half inch in thickness, but more usually as crystalline aggregates up to 10 lb. weight. At Betilonga village and in the Sutakiki Valley the mineralisation is accompanied by minor amounts of copper, silver, gold, lead and barytes. The commercial possibilities of these and other areas of Basement Complex rocks are dealt with in the section on Economic Prospects.



PLATE II

Outcrop of folded and faulted Toni Tuffs exposed in the Toni River of Central Guadalcanal

The Metapona Beds

This sequence of sediments represents a period of large-scale sedimentation over central Guadalcanal, beginning in the late Lower Miocene with the deposition of essentially calcareous sediments and continuing, possibly with interruptions, well into the Upper Miocene with the deposition of pyroclastic material.

In the western part of the area the sequence in ascending order is made up of the Betilonga Limestone, the Tina Calcarenite, the Tangaraisu Marl and the Toni Tuffs. In the east the Betilonga Limestone cannot at present be traced beyond the Tinahula River. East of Gold Ridge and the Berande River it has its stratigraphical equivalent in the Lake Lee Calcarenite. This is overlain by the Berande beds, of which the basal part may be equivalent to part of the Toni Tuffs.

The Betilonga Limestone is biostromal, a calcarenite of microcoquinoid type, strongly cemented, the lower part with chips and subangular pebbles of lava and tuffaceous agglomerate. It is often brecciated and recrystallised but not well bedded. The colour ranges from white to yellow, the brecciated examples having red haematite veins filling the breccia cracks. Foraminifera, calcareous algae, broken down fragments of mollusca, echinoid spines, bryozoa and ostracoda make up the bulk of the rock; actual reef coral is fairly rare. The agglomerate and lava fragments are apparently derived from the underlying Basement Complex. The larger foraminifera include species of *Eulepidina*, *Miogypsinoides* and *Miogypsina*, indicating a late lower Miocene to early middle Miocene age for this limestone ("e" to "f" boundary under the obsolete letter classification); the approximate European equivalent would be late Aquitanian, perhaps early Burdigalian.

The best exposures so far found are at Betilonga village, where the Tenaru River flows into a large cave; and at a very prominent hairpin bend on the middle reaches of the Tina River, where it has intercalated tuffaceous shale layers which define the bedding. The nature of the contact with the Basement Complex is unknown; only fault contacts have been found so far. Faulting prevented an accurate estimation of thickness; at a minimum it is of the order of 500 ft. The regional dip of the formation is 15° to 20° to the north.

The Tina Calcarenite is a bedded clastic sediment composed of abundant fresh and altered feldspar and hornblende crystals, small lava fragments, shell material and foraminifera, strongly cemented by calcite. The grain-size varies from less than 0.1 mm. to 2 mm. The bulk of the rock is made of the finer grains, less than 0.5 mm. Colour varies from grey to yellow-brown. Some outcrops show intercalated fine-grained mudstone partings in which the tuffaceous element is dominant. Small foraminifera are common but not well preserved. Occasional specimens yield larger foraminifera, including *Nephrolepidina*, *?Trybliollepidina* and *Miogypsina*, indicating an approximate middle Miocene age for this sediment. The regional dip is again 20° to the north in conformity with the underlying Betilonga Limestone. The thickness is estimated to be 300–400 ft.

Although considered separately the Tangaraisu Marl has been seen only in the area of the headwaters of the Tangaraisu River. It may be a lens-like body, representing a restricted special environment during late-stage deposition of the Tina Calcarenite. Lithologically, however, it is a distinct and easily recognisable body. The

nature of the lower contact is unknown. The regional dip is the same as that of the underlying sediments.

The Tangaraisu Marl is characterised especially by the prevalence of large foraminifera, especially of individuals of *Multilepidina* sp. These make up at least half the bulk of the rock, the lens-shaped tests defining the bedding. The surrounding matrix is made up of smaller foraminifera (not in large numbers and not stratigraphically valuable) and of tuff, overall a crystal tuff with a minor amount of lithic fragments. The colour is a light blue-grey, resulting from the blend of white foraminifera tests and dark grey matrix.

Multilepidina is a south-west Pacific genus of doubtful taxonomic position. Its presence usually indicates a middle Miocene age for the containing sediment.

The thickness of this Marl is estimated to be little more than 200 ft.

Neither the Tina Calcarenite nor the Tangaraisu Marl seem to persist east of Gold Ridge, i.e. east of the Sorvohio River.

The sedimentary bodies so far described are probably true formations in the normally accepted sense of that term. The overlying mass of largely pyroclastic sediments, however, probably consists of several formations. The nature and extent of these will require more detailed mapping than has been possible up to now. Collectively they are characterised by a strong "crystal-tuff" content, and by a fauna of small foraminifera, usually an impoverished one with many pelagic forms, including *Orbulina universa* d'Orbigny. For lack of better terms, "tuff" and "pyroclastic" are used to describe them, although a large part has certainly been re-worked and has experienced some water transportation.

Almost any traverse up the north-flowing streams, between the Lunga and Balasuna Rivers, will pass through a mile or so of these sediments, the Toni giving as good a section as any: hence the name, Toni Tuffs. To the south they dip regionally 15° to 20° to the north, conformable with the underlying sediments. Over the middle part of the area they tend to flatten out so that dips of 10° or even 5° become more common; this is a generalised field impression: the large number of faults tends to obscure the structure.

There is considerable lithological variation vertically and laterally. In the lower beds fine even-grained crystal tuffs are common. Some are consolidated, with a calcareous cement derived from the small foraminifera frequently present. Others, although also containing foraminifera, are rather friable even in fresh outcrop. The finer grained (less than 0.2 mm. average grain size) types may show bedding sufficiently fine for them to be termed shales; the coarser grained (with fragments up to 0.5 mm.) most frequently lack fine bedding and only large outcrops show evidence of structure. The bedding in these, as in the fine tuff-shales, may be defined by occasional gritty layers or by carbonaceous films. When broken down and the clay fraction (always a considerable amount) washed out, the grains are found to consist of crystals of feldspar (much of it labradorite), amphibole, including hornblende and hypersthene, a little quartz, a

little augite, mica and rare lava fragments often chloritized. Generally, the feldspar and amphibole crystals, often fresh and little worn, make up the bulk of the non-organic material. This may be a reflection of the andesitic lavas which make up the large part of the Basement Complex. Small foraminifera amount to as much as 10% of the rock: the fauna they represent is usually a poor one in numbers of species.

Higher in the sequence coarser-grained and less-well-sorted sediments become more typical; grits and small-pebbled conglomerates and agglomerates are common. This trend is especially obvious in the eastern part of the area. The change is more in texture than in composition although the foraminifera occur more sporadically: some bands are very rich in foraminifera, so much so that the rock might be termed a tuffaceous calcarenite, but are separated by layers almost devoid of foraminifera. These barren tuffs instead may contain macerated plant debris and may be lacustrine or lagoonal.

Some of the ridges in the Tenaru River valley are capped by biostromal limestone. It is not known if these are part of a single formation or are discrete lenses in the surrounding pyroclastics. Lithologically they resemble both the Betilonga Limestone and the limestone in the Mt. Austen Beds. Unlike the latter, they contain specimens of *Nephrolepidina* species, apparently not derived. The presence of this form, together with their stratigraphic position indicate an early upper Miocene age for this part of the Toni Tuffs.

The sequence ending with the Toni Tuffs breaks down east of the Balasuna River. In this part of the area the Basement Complex (here largely made up of "green rocks"—greenish shattered and sheared altered lavas) is directly overlain by a biostromal microcoquinoid or calcarenite, herein called the Lake Lee Calcarenite because of good exposures making up the cliffs north of Lake Lee. In appearance and composition it is very similar to the Tina Calcarenite, but it contains numerous *Eulepidina* spp. and a fauna very like that of the Betilonga Limestone. The Lake Lee Calcarenite is regarded as the stratigraphical equivalent of the Betilonga Limestone but differing in lithological facies. On the other hand, it may not be directly connected with the Betilonga Limestone. The question of discontinuity between Miocene sediments in the western and eastern parts of the area is discussed in greater detail in the section on structure.

The Berande Beds conformably overlie the Lake Lee Calcarenite. They commence with a white biostromal limestone in which are intercalated layers of dark blue and dark grey tuffs and tuffaceous shales. Despite intensive examination of many samples no orbitoid or other foraminifera indicative of a lower or middle Miocene age have been found. The fauna generally is more suggestive of a later upper Miocene or Pliocene age; it includes species of *Amphistegina*, *Cyclocypeus*, *Globorotalia*, *Globigerina*, *Heterostegina*, *Operculinella*, *Pulleniatina*, *Sphaeroidinella* and *Orbulina universa* Linnaeus. This lower part, in which limestone or calcareous sediments predominate, is several hundred feet thick. Above this the Berande Beds appear to be largely pyroclastic, com-

posed of tuffaceous shales, fine and medium grained tuffs, tuffaceous grits and agglomerates and conglomerates. There seems to be a general coarsening in grain size towards the top of the beds. The changes from one type of pyroclastic to another are very rapid laterally and vertically: not enough is known at present to attempt any formal distinction between one and another. The richly calcareous sediments are missing, although many samples of the fine-grained material contain abundant small foraminifera.

The regional dip is to the north-north-west at 15° to 20°. This is a provisional estimate, as local dips vary widely due to faulting. The thickness is at least 3,000 ft. The Berande Beds are thought to be the stratigraphic equivalent of the upper part of the Toni Tuffs and the lower part of the Mt. Austen Beds, the bulk of them being Pliocene in age.

The Tina Calcarenite and Tangaraisu Marl are missing in this eastern part of the area.

The Mount Austen Beds

This name is applied to a largely undifferentiated mass of sediments which overlie the Miocene sequence. They are fairly well typified by the sediments seen in stream traverses running down from the hummock of Mt. Austen, west of the Lunga River mouth, and along the middle reaches of the Tenaru River. A complete picture, however, requires sections from the rivers to the east.

The beginning of the Mt. Austen Beds is marked by widespread coarse grained clastics, especially thick layers of conglomerate and agglomerate, with pebbles up to 6 in. in diameter. These are called the Tenaru Conglomerates, excellent exposures being seen in this river, upstream from Belahaha village. The transition from the underlying Toni Tuffs is usually very abrupt, even though the upper part of the Toni Tuffs may contain much coarse material. It may be seen in many of the north-flowing rivers, especially in the middle reaches of the Tenaru, the Toni, Tinahula and Sorvohio rivers; also on some of the ridges between these streams even up to heights 1,600 ft. above sea level. It is likely that this transition does not represent a single stratigraphic horizon; the Tenaru Conglomerates probably represent a period of intense and rapid sedimentation which began at slightly different times over different parts of the area.

The pebble and boulder rock types in the west are mainly of hypersthene-augite andesite, and, occasionally, of diorite. The eastern outcrops are more variable in rock type: the pebbles include andesite, including propylitized andesite, tuffaceous agglomerate, rare diorite, occasional altered green rocks of the Basement Complex, and rare Miocene limestone. The matrix in most outcrops appears to be a re-worked tuff. Beyond these points, no general description can be made. Some sections show layers of very coarse, poorly sorted conglomerate with well-rounded pebbles ranging from 1 in. to 6 in. in diameter, the distinction between pebble and matrix being very distinct, and compacted so that the matrix is confined to the interstices (e.g. Tenaru River outcrops). The conglomerate layers may be 50 ft. thick

and separated by bands of grits of irregular thickness, re-worked coarse and fine grained tuffs, and tuffaceous shales. Another section may show a more strict alternation, in regular and equal thickness, of bands of conglomerate, angular conglomerate, grits and finer-grained tuffs. Some conglomerate bands are compacted, in others the matrix is dominant over the pebble constituent. Further traverses show yet other variations. The change-over from one sort of sediment to another, laterally and vertically, is sometimes gradual and sometimes abrupt.

The Tenaru Conglomerates merge gradually into the overlying remainder of the Mt. Austen Beds. These are comparable in lithology with the upper part of the Toni Tuffs but are fresher looking, contain more bands of macerated plant debris and have bands rich in foraminifera representing a fauna of decidedly more recent aspect. They are undifferentiated here because of their lithological variation and disruption by faulting.

The sequence at Mt. Austen shows coarse crystal tuffs with which are associated lenses of white biostromal limestone. To the south, these give way to, or are faulted against, a thicker set of black to dark-grey foraminiferous tuffaceous shales. These are followed by fine and coarse grained crystal tuffs containing foraminifera and with a calcite cement; the bulk of Mt. Austen is composed of these tuffs. Some of them have been re-worked and sorted; certain layers consist of felspathic tuff, in which most of the inorganic fragments are of euhedral and subhedral plagioclase (usually labradorite), others have subhedral hornblende or augite predominant. The elevated terraces which have been described as the Honiara beds in a previous report, lap up onto Mt. Austen.

To the east the Mt. Austen Beds in general are coarser grained, are less fossiliferous and less well bedded. The contact with the underlying Berande Beds is sometimes disconformable, but more often shows an unconformity, the conglomerates resting at an angle on an eroded base. This contact is probably younger than the Toni Tuffs-Tenaru Conglomerates contact in the west, as the black and dark-grey tuffaceous shales of the Mt. Austen section have their lithological counterpart in the upper part of the Berande Beds, and, more importantly, have a similar fauna. This fauna, common in the Mt. Austen Beds, is distinguished by abundant small rotaliid species, *Marginopora*-species, a profusion of species of *Amphistegina*, *Calcarina*, *Operculina* and *Operculinella*, and, especially, by the presence of large *Rotalia*-species of the *schroeteriana* kind. This is very probably a Pliocene fauna.

The Mt. Austen Beds are at least 3,000 ft. thick in the Berande River area, and 2,000 ft. in the Mt. Austen area. The regional dip is 10° to 15° to the north, tending to flatten as one goes north.

The Nalimbu Alluvials

These at present are defined mainly by the great grass-covered coastal plains of northern Guadalcanal, which extend east from Honiara to beyond the Bokokimbo River in eastern Guadalcanal, and average five to six

miles in width from north to south. They lap up onto the southern foothills, composed of Mt. Austen Beds, and encroach up to the valleys of the larger rivers; to the north they merge into the present-day off-shore sediments. The surface is remarkably smooth and appears to be at the one level, with a very gentle slope to the north, although there are occasional low hillocks, mounds and shallow depressions. Whether the surface is substantially at the same level or whether there are several levels with small vertical separation cannot be decided without accurate topographic survey. By and large, the present plain seems to be a eustatic feature upon which may have been imposed minor fault movements represented by the minor irregularities.

The plain is erosionally stable for the most part; only the coastal area is being built up by periodic flooding and by the seawards extension of the river mouths, some of which are on growing deltas (e.g. the Lunga River). It has, however, resulted from a long period of accumulation. Old soil profiles with grass roots have been encountered in bores 150 ft. below the surface (Baker, 1950). This is further illustrated by the thickness of alluvial gravels in the lower reaches of the Sorvohio River (Grover, 1955, p. 29).

The sediments composing the plain consist of poorly consolidated conglomerates, gravels, grits, sands and mudstones, none of them persisting very far, laterally or vertically. They show wildly fluctuating local dips up to 10°, but the regional structure is a gentle dip to the north. They persist unconsolidated to depths of at least 500 ft. In the coarser beds the pebbles represent most of the rock types so far described—even the comparatively soft tuffs and tuffaceous shales—but the relative proportions are unknown. To casual observation, andesite seems predominant. Some beds consist almost entirely of very well rounded pebbles, others show only subangular ones; sorting is generally poor. Except for plant debris, fossils do not seem to occur: this might reflect the lack of collecting.

The general characteristics of the Nalimbu Alluvials are those of a sediment rapidly deposited, transported over a short distance from a source area of high relief and undergoing rapid erosion.

Structure

Faulting is the dominant structural expression in the area. Apart from minor undulations there is no folding. The structural picture, in summary, is one which shows a thick, wedge-like cover of sediments resting unconformably on heavily faulted basement igneous rocks, the faults for the most part vertical or high angle: the overlying sediments reflect movement in the basement blocks.

The Miocene to sub-Recent sediments are of shallow-shelf type, for the most part structurally incompetent. Their dip values tend to decrease up-section, from 20° to 25° for the Miocene basal beds to 5° to 10° for part of the Mt. Austen Beds—the sort of gradual change typical of a shelf which underwent gradual subsidence during deposition. It is not likely, however, that the thickness is as great as one would expect from calculation based

upon the dip values given (a thickness of the order of 10,000 ft. within three miles north of the present outcrop of Betilonga Limestone). This opinion is based on the fact that the sedimentary cover over most of the area reflects basement faulting fairly closely and also that outliers or windows exposing basement or Miocene Limestones are bounded by faults which as seen on the ground and in aerial photo could not have the enormous throws otherwise required. At no point in the area is the thickness estimated to be much more than 6,000 ft.

There is insufficient data to attempt a description of the detailed structure of the sediments. It is certainly more complex than that given—a fault-disrupted wedge of sediments in which the thickness increases rapidly at first and then remains constant. A few of the outstanding stratigraphic problems will illustrate this.

The first concerns the connection between the Miocene section west of Gold Ridge and that east of the Balasuna (or Sutakama River). The Betilonga Limestone has its stratigraphical equivalent in the Lake Lee Calcarene. If the two formations be provisionally regarded as a single depositional unit, changing in lithological facies from a near-massive limestone in the west to a calcarenite in the east, the problem exists of establishing the presumed line of continuous outcrop. On regional evidence this should be found over a traverse from Gold Ridge to Mt. Jonapau to the Sutakiki valley. Several such traverses have failed to establish it, although the southern slope of Mt. Jonapau offers approximately 2,000 ft. of Toni Tuffs before the Basement Complex of the Sutakiki valley is reached. Its absence is probably due to faulting, the Basement Complex being upfaulted against the Toni Tuffs. If so, the faulted-out interval persists east to the Balasuna River, possibly beyond, and over the same interval the Tina Calcarene, the Tangaraisu Marl and a large part of the Toni Tuffs must lense out and disappear. In turn this means that the part of the area east of Gold Ridge did not receive sediments over much of Middle and, possibly, Upper Miocene times. It is not thought to be an eroded break because of the conformity of the Lake Lee Calcarene and the Berande Beds.

A similar problem existing is shown in passing from the section east of the Lunga River to the section south of Mt. Austen. On present evidence, in a distance of about a mile west along strike, the larger part of the Toni Tuffs progressively fails to outcrop. The lower reaches of the Lunga River appear to represent an important structural and sedimentary break.

The above and similar problems are obviously bound in with the fault systems now described.

Both the sediments and basement are trellised by faults large and small. On the ground it is often extremely difficult to judge the relative size and structural importance of a particular fault due to the depth of weathering, small outcrops, and the pervading jungle cover. In these respects, and in conjunction with ground data, the aerial photographs are an invaluable aid in interpretation.

By and large, it appears that the larger faults are confined, to a surprising extent, to the orientations north-

west to south-east and east-north-east to west-south-west. The relative movement along the fault planes is mainly vertical with slight slip components. There does not seem to be any significant difference in size or structural effect between the faults of one set and those of the other; expressed in another way, no few "master" faults can be determined as primarily responsible for the consequent fault pattern.

The overall effects of the large-scale faulting are of successive block uplift from north to south (the most obvious) and of shearing, the northern blocks tending to show movement east with respect to the southern. Neither of these effects is in any way uniform—some blocks have a graben relationship to those immediately adjacent—but the general uplift is even; the most uplifted part of the area, the Kavo Range, with peaks up to 8,000 ft., is approached gradually. It is not thought, however, that these central mountains are the exclusive result of step-faulting—areas of basement exposure are not large enough for this—but that the step-faulting is a secondary structural expression of a general geanticlinal warping of the area, the axis of warping being roughly east to west.

As might be expected, there are a host of minor faults associated with the larger ones. They can be generally described under three headings: first, the minor faults, showing tension features, which run *en echelon* on either side of the larger faults or join adjacent faults diagonally; second, minor faults which terminate the larger faults in a "horse-tail" pattern; third, faults which are not large and cannot be structurally related to other faults. Most of these minor faults are tear faults, some of them showing up to 1,000 ft. of relative lateral movement, but the majority show far less. Some river traverses pass through a succession of them (in the Tinahula, for example, one passes through 20 in a mile). The courses of these rivers are thereby much influenced and indicate lateral movement for a lengthy period up to the present time. The course of the Tinahula, in its middle reaches, is a series of right angles, the river flowing up against one scarp after another and diverting right or left. Such a traverse may give the initial and erroneous impression that one is passing through alternately uplifted blocks, whereas in fact the blocks are laterally translated parts of the valley wall; one may also imagine that the sequence is a good deal thicker than it really is.

As already mentioned, there is little folding. The few local undulations are associated with minor faults and may be due either to these faults being antithetic to the larger faults resulting in local reverse dips; these, in turn, giving the impression of folding, or of indirect reflection of basement fault movements by the mass of incompetent sediments.

A little can be said of the structure of central Guadalcanal south of the area described. Here the Kavo Range falls rapidly to the coast. The fault lines seen in the aerial photos follow a similar pattern to that of the north, but there are fewer of them, they are better defined, and have pronounced topographic effects indicating large vertical components.

The tectonic structure can be summarised as follows : the area is part of a general geanticlinal upwarping affecting much of the island. This warping has been accommodated in the igneous basement and most of the overlying sediments by numbers of vertical or high angle faults, resulting in a jostled rhomboidal-mosaic of fault blocks. The two prevalent strike directions of these faults are north-west to south-east and east-north-east to west-south-west, respectively. In general the blocks are successively uplifted from north to south. Directly associated with these larger faults there are numerous minor faults ; some are antithetic, some in the nature of gash or tension fractures and some are of the tear variety. The occasional small folds are considered to be the result of antithetic faulting or to the absorption of large faults by incompetent beds high in the sedimentary section. Finally, the primary warping is possibly asymmetrical, the north slope being less steep than the southern one.

The age of the warping and consequent faulting can be decided as follows : The Miocene (later lower Miocene) calcareous sediments are of shallow shelf type in which the terrigenous element is subsidiary. The overlying Toni Tuffs include crystal tuffs, explosively derived, re-worked crystal and lithic tuffs, and a considerable proportion of grits and polymictic conglomerates. These in turn are overlain by a sudden preponderance of conglomerates and agglomerates with crystal and lithic tuff matrix—the Tenaru Conglomerates—of supposed middle-upper Pliocene age. The remainder of the sediments have characteristics indicating that the area received sediments from a province undergoing uplift with consequent rapid erosion, the sediments suffering little transport. These, the Mt. Austen Beds of Pliocene (upper Pliocene?) age, also include products of explosive vulcanism.

The crustal activity which led to the outstanding structural features of the present day is thought to have begun in late middle Miocene time ; the upwarping became accentuated and perhaps subjected the area to erosion in upper Miocene times. Although pulsatory and intermittent, the climax of uplift and the major faulting are considered to have taken place in the middle or upper Pliocene. This activity has continued to recent times, as instanced by the presence of the Nalimbu Alluvials ; the present topography has an intimate relation to the structure. Vulcanism has proceeded intermittently since the middle Miocene.

This is an abbreviated and simplified outline ; the process was certainly not as progressively straightforward as indicated. The evidence on pre-Miocene structure and structural history is too sparse to be integrated.

Economic Prospects

Large areas of exposure of heavily mineralised rock in both Basement Complex and overlying sediments are an encouragement to detailed prospecting. The mineralisation is usually indicated by abundant metallic sulphides, especially pyrite ; they occur as granular aggregates,

cavity fillings, veins or disseminated through the country rock.

Most of these deposits can be summarily described as epithermal by-products of hydrothermal activity which has resulted in metasomatic replacement of the country rock and the infilling of joints, shear and shatter zones, minor faults and fault intersections, with sulphides very often associated with secondary quartz. The exposures are sporadic and do not seem to be linked with any single controlling structure. They vary also in intensity of pyritisation, so that some outcrops showing abundant syngenetic pyrite, for example of diorite or propylitized andesite, may at first give the impression of secondary mineralisation.

In certain localities the sulphides have been proved to carry gold and, to a lesser extent, other valuable metals such as silver, copper and lead. These are Gold Ridge, Betilonga, and the Sutakiki Valley. Their histories of exploration, geology, analyses of samples and other details are discussed in Grover, 1955. Gold Ridge is the most important, and the best known, as a potentially exploitable deposit. Here the gold is derived mainly from quartz veins and stringers which penetrate the country rock, part of the Toni Tuffs. The Ridge itself is made up of tuffs, re-worked tuffaceous mudstones and shales, and andesitic agglomerate, seamed with faults and much shattered as a consequence. The gold is widely disseminated and, so far, no major ore-body has been found.

Although it possesses the necessary features and has been described as an epithermal deposit, the igneous source providing the hydrothermal activity is unknown. A few dykes are thought to be present (the ridge is deeply weathered and in small exposures by costean or adit it is difficult to confirm the presence of an intrusion as distinct from the agglomerate present), but a large number, a "swarm", would better account for the widespread character of the mineralisation. It has also been suggested (in Grover, 1955, p. 76) that eroded flows could have been the igneous source, a suggestion based on the presence of andesite boulders on neighbouring ridges ; these, however, are almost certainly erosional relics of the Tenaru Conglomerates.

There is another possibility, that the diorites of the Basement Complex are not stratigraphically part of the basement at all, but are stocks which have been intruded at the time of the post-Miocene upwarping of the area. The Gold Ridge mineralisation, and that of the many other localities, might then be genetically related to the diorite and together represent a single mineralising episode.

At the moment this is purely conjectural : the relation between the diorites and the pre-Miocene lavas of the Basement Complex is unknown. In western Guadalcanal similar diorites have been proved to be younger than associated basement lavas similar petrologically to those of this area ; but they have also been proven to be pre-Miocene.

The alluvial gravels of the lower Sorvohio River are gold-bearing, the gold being derived from Gold Ridge. They have not been regarded as a commercial proposi-

tion, but recent developments in dredging methods makes it a possibility that they be worked profitably.

In conclusion, although Gold Ridge has not yet fulfilled the first hopes held of it, there are other localities which are heavily mineralised and important because of their gold possibilities. Yet others will probably be found. It is suggested that the most promising localities are those in or adjacent to the Basement Complex, wherever basal Miocene beds are exposed, e.g. Betilonga or the middle reaches of the Tina. Each locality deserves serious attention; the regional picture fully justifies expectation of commercial gold discovery in the area.

The potential of the area as a petroleum producer is the other important economic aspect. The Miocene sedimentary sequence is quite promising: it is thick, it includes source beds, potential reservoir beds and a sufficient cover of sediments to seal in any petroleum accumulations. The succession is good; the basal calcareous sediments, massive limestones and calcarenites, have high values for initial porosity and permeability, some of them also being cavernous, and so would make excellent reservoirs. Their organic content, and that of the sediment immediately associated with them, must have been high judging from their present fossil content and their biohermal nature. Above these there is a thickness of relatively barren material which includes sufficient poorly-permeable sediments to act as an effective seal. Stratigraphical traps are provided for in the lateral variations in lithology characteristic of so much of the sequence.

The remaining Pliocene to Recent sediments are less promising; they are less thick than the Miocene sediments, they lack the abundance of calcareous sediments, and the succession of lithologies is not so conducive to oil accumulation.

In all, there is an effective area of 500 square miles with a sedimentary thickness of up to 6,000 ft. over much of it; the necessary lithologies are present arranged in promising successions. Stratigraphically this is an attractive "pocket" area.

In its structure the area is less promising, not so much from the point of view of initial accumulation as from the effects the structure has had on accumulations and the difficulties it imposes on exploration and subsurface interpretation.

The lack of folding and the intensive faulting do not furnish conclusive evidence that there has not been accumulation of petroleum in the area. The major faulting has resulted in successive uplift from north to south so that the basal beds, the potential reservoirs from up-dip migration of petroleum, are conceived of as faulted against basement rocks to give stratigraphical-structural traps. On the adverse side, this same faulting is so intense that the traps are likely to be small and the shattering of the basement lead to thinning-out of an accumulation. The purely stratigraphical traps would also be adversely affected; only small traps would escape disruption. Again, the major faults are considered to affect both basement and the overlying sediments so that the apparent absence of seepages becomes significant,

implying either an absence of petroleum or its dissemination in a host of minor secondary traps.

Salt-water and sulphurous-water springs occur in the area. Considered alone their presence is perhaps favourable, but they occur very often in proximity to epithermally mineralised localities and so may have their real connection with these; indeed, the prominence of these mineralised localities around and about the contact between Basement Complex and Miocene sediments is an unfavourable feature affecting the southern third of the area.

Nevertheless, the area should not be disregarded as a petroleum prospect. Its stratigraphical and lithological characters are favourable in this regard; its structure is less favourable. Detailed surface mapping is certainly warranted, especially to establish whether or not the fault patterns are as basically simple as present information would indicate. A restricted test-drilling programme would not reflect over-optimism. On present information this might be confined to three localities, two on the southern edge of the grass plains to the north-east and north-west of Gold Ridge, respectively, and the third on the coast at the mouth of the Metapona River.

Palaeontology

The sediments of central Guadalcanal are relatively rich in stratigraphically diagnostic large foraminifera, especially orbitoids. These have enabled a fairly precise age estimate and biostratigraphic subdivision of the Miocene part of the sequence. The important genera are mentioned in the stratigraphic discussion. These large foraminifera are now being studied in detail; the results may fill an important gap in knowledge of the taxonomy, stratigraphic and geographic distribution of large foraminifera in the South-West Pacific region.

The smaller foraminifera comprise faunas essentially similar to those described in an earlier report on the geology of western Guadalcanal. These small forms are of limited use. With further detailed collecting and the refinement of stratigraphy brought about by study of the large forms, they should be of greater stratigraphic use and especially useful in delineating facies changes in the area. At the moment they do not enable a precise definition of the Miocene-Pliocene boundary in the area. This has been fixed approximately by the sudden influx of Recent forms and of large *Rotalia*-species—criteria that are suggestive rather than conclusive.

Physiography

There are three physiographic divisions in the area—the northern plains, the Central Highlands, and the intervening foothills.

The Central Highlands are a system of block-faulted ridge mountains in which isolated and prominent peaks are rare. Many of the ridges are over 4,000 ft., and include Mount Popamanasiu, 8,005 ft. (the highest), Mount Latinarau (6,540 ft.), Mount Balamarau (5,800 ft.)

and others, some of them unnamed as yet. They fall rapidly to the south to a faulted coastline; to the north they pass more gradually into foothills. They tend to have an east-west orientation, with even profiles longitudinally, but often razor-backed in section, with steep sides descending to deeply dissected narrow valleys.

The drainage is to both north and south. The south-flowing rivers are short, sharply incised and immature. Their courses are very often defined by faults and they have many waterfalls and steep rapids. They are subject to sudden and heavy flooding. The north-flowing rivers capture most of the run-off. Again, large parts of their courses are fault-defined, and although at a youthful stage are more evenly graded and have wider valleys than those draining to the south. Overall, the main courses of the streams appear to be structurally controlled, the minor tributaries subsequent upon the rock type and the flow cleavage in the Basement Complex. The pattern is of the open trellis-type.

The foothills connect the high mass of the mountains to the northern plains, occupying a belt from five to 10 miles wide. They consist of north-sloping ridges which splay out on to the plains, and of large block-like masses, tilted to the north, which are intricately dissected. The rivers are at an advanced youthful stage, their main courses fault-defined and, over small stretches of their courses, very much affected by small tear faults which result in "shutter" spurs. Because of block faulting they show many examples of superimposed and antecedent features. The general pattern is trellis-type; the minor tributaries often show herringbone patterns consequent upon rock types.

Both foothills and highlands are covered with tropical jungle vegetation. Above 3,500 ft. this gives way to bamboo thicket and moss forest. Although there is a heavy rainfall, the vegetation prevents sheet erosion. Most of the corrasion suffered by the country is due to headward erosion by the streams, valley collapse, and landslide; the last is especially prominent.

The northern plains are discussed in the description of the Nalimbu Alluvials.

The general surface slopes south to north, falling from over 30 ft. to the coast over a distance of up to five miles. The rivers are now of large size but still youthful. Only near the coast are mature characteristics developed, graded reaches attained and delta flats with distributaries built up. Except along the banks of the rivers and in shallow depressions, the plains are covered with tropical grasses of the tall Kunai-grass variety.

In summary, the topography, drainage and vegetation of the area are intimately controlled by the geology and structure. The faulting has caused the major profile and controlled the broader features of the drainage. Rock type plays a lesser role although each of the main rock types has its own characteristic topographic expression. Thus, in the foothills area the pyroclastics contribute the dendritic and herringbone drainage patterns of the tributaries to the main streams. The limestones show many features of karst topography wherever they are gently inclined and have no overlying sediments; the

southern outcrops are rather steeply dipping and tend to form high ridges with well defined northern dip-slopes. Without overlying sediments the diorites and lavas of the Basement Complex may show open valleys, rounded ridges (except in the Highlands proper), and an open trellis drainage pattern; the more shattered and metamorphosed lavas to the east tend to develop very youthful topography with many insequent drainage features which may reflect the rock cleavage.

Correlations with Western Guadalcanal

The formal correlations between the rocks of western Guadalcanal and those of this area are not attempted here. These will be done in a separate paper on the regional geology of Guadalcanal, which has been in preparation, along with this report, for some time. As soon as it is completed it will be forwarded to the Chief Geologist. The following interim correlations are suggested: the Bonege Limestone, in whole or in part, with the basal calcareous sediments of this area, the Betilonga Limestone, the Tina Calcareenite and the Tangaraisu Marl; the upper part of the Toni Tuffs with the Metanakau Tuffs—the latter are probably the basal part of the Mt. Austen beds, as they are found in the west; the Umasani tuffs with the upper beds of the Mt. Austen Beds; the Honiara Beds with lower parts of the Nalimbu Alluvials. The dioritic and andesitic rocks of both areas have many petrological characters in common.

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NOTES ON GEOLOGICAL RECONNAISSANCES ON CHOISEUL, 1957

By P. A. PUDSEY-DAWSON

The Chief Geologist made two coast-to-coast walks across the island in 1956*. In late March 1957 I made two similar trans-island traverses as well as a coastal one, and also a short excursion inland from Sasamunga. This was preparatory to the main survey by Dr. Coleman† in May and June of this year. Mr. Thompson assisted in this undertaking for three weeks as part of the ultrabasic research project of which he is in charge: he later returned to finish mapping the south-eastern end of the island.

limestones back the shoreline but do not extend far inland.

On the small offshore islands and along the coast to the east of Kumboro are badly sheared coarse gabbroic rocks. There is much faulting.

From Posarai crossing was made to Vure, following the Goga and Otaga Rivers. The country was extremely rugged with very narrow, high, steep-sided valleys. There was an almost continuous rock outcrop in the Goga River until we left the stream and climbed over the central

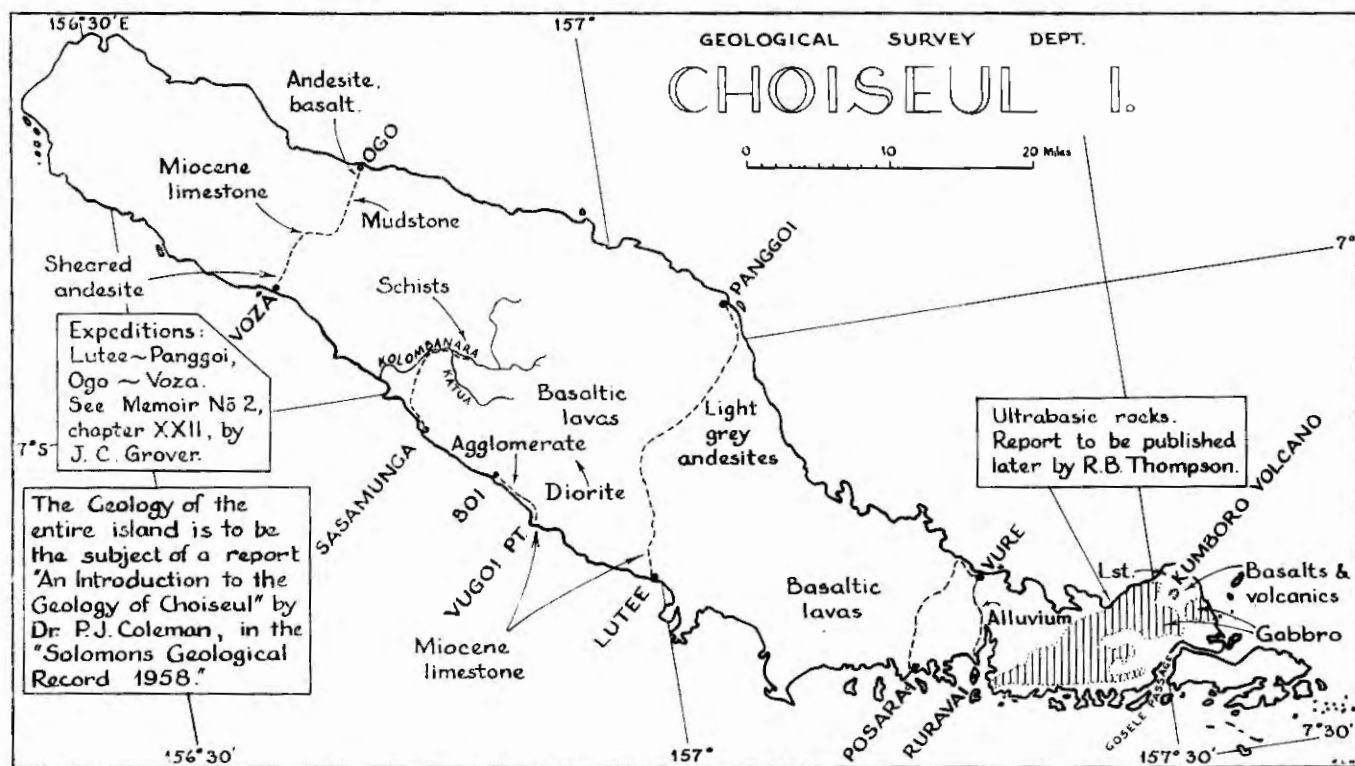


FIG. 4.—Sketch map showing routes taken

I made a two-day visit to the Kumboro Peak area and climbed the well-preserved volcanic cone: it appears as a narrow horseshoe-shaped ridge, breached to the south by a large river that drains into the Nggosele Passage. The upper slopes are extremely steep and difficult to climb, consisting of agglomerates weathered to a red-brown soil. Beneath the summit ejectamenta, ropey basaltic lavas are exposed in the stream beds. On the western side of the volcano pinky-white porcellaneous

divide at a height of about 1,800 ft. (where we slept the night). Descending a steep cliff we reached the Otago River at a height of 750 ft., where the basaltic rock was coarser than that seen previously. The valley here was again narrow and rocky, but opened out beyond a 100-ft. waterfall at a large river junction with wide alluvial terraces on either bank. No rock exposures were seen again until we reached the coast, where ropey, basaltic pillow lavas outcropped to the west of Vure village.

Leaving Vure, we crossed back to Ruravai on the south coast, keeping to the Otaga River through a wide

* See Chapter XXII of Memoir No. 2, 1958.

† See Report No. 4.

alluvial, partly-swamp valley. The banks were of a semi-compacted clay, reminiscent of an old deposit rather than a recent alluvial one : it was blue-grey in colour with the texture of modelling clay. A washed sample showed it to consist of about 80 per cent clay with a residue of rock fragments and heavy minerals (ilmenite and magnetite). No foraminifera were found.

Ruravai Island is of fine well-bedded sandstone with a westerly dip of 5°.

Landing at Sasamunga Mission, we crossed over to the Kolombangara River and followed this up to the confluence with the Katua River. As far as the junction the valley was wide, alluvial-filled, with pebbles of basalts, agglomerates, schists and mudstones. At the

junction we had to turn back due to the short time at our disposal.

A coastal traverse from Vugoi Point to Boi completed the short reconnaissance. Limestones outcropped at Vugoi and showed great variation from massive to soft and chalky varieties.

A small collection of pebbles from the Bannanoi River showed the presence of diorites, fine basalts, and consolidated breccias. West of Nambusasa village basaltic pillow lavas outcropped along the beach, but westwards this gave way to a muddy siltstone overlying a volcanic agglomerate which dipped north-east 15° and outcropped continuously as far as the village of Boi : where we were picked up by *Noula* for the return to Honiara.

AN INTRODUCTION TO THE GEOLOGY OF THE ISLAND OF CHOISEUL IN THE WESTERN SOLOMONS, 1957

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(The reader is advised at this stage to open out the geological maps and sections at the rear of this chapter.)

This report is the result of a reconnaissance survey of Choiseul Island, part of a programme of geological reconnaissance of the islands of the Protectorate, begun in 1950. As a result of representations made by Mr. J. C. Grover, Chief Geologist, the Western Pacific High Commission invited me to do this work.

Prior to 1957, geological knowledge of Choiseul Island could be described as meagre; it was contained in a report of trips across the middle of the island in the Ogo and Mount Matambe areas made by Mr. Grover in 1954.

Field work was carried out during May and June 1957. Although hindered by bad weather and rough seas, this consisted of five cross-island traverses, about 30 miles of other traverse up and down various rivers and about 40 miles of selected beach traverse. Nearly two-thirds of the coast was examined from the Geological Survey Department's motor vessel *Noula*, landings being made at selected points. The data yielded by this work was supplemented by the ground observations and specimens given me by Messrs. Thompson and Pudsey-Dawson, geologists with the Geological Survey Department. Mr. Thompson made an independent survey across the island and was a valued assistant for the last two weeks of the season; Mr. Pudsey-Dawson had made a quick reconnaissance of parts of eastern Choiseul, shortly before my arrival, and sent me information and specimens collected from the Kumboro Peak area. Finally, Mr. Grover did a short coastal traverse west of Kumboro in March 1958, and sent me his results. These same officers of the Department helped me in many other ways, often at considerable inconvenience and personal discomfort. To them, and to other officers of the Administration, I am greatly indebted.

Aerial photographs were used to compile field sheets of the whole island on a scale of 1 : 40,000 (approximately 1½ in. to the mile); these showed rivers, coastline, reefs and other physiographic features in fair detail. With the additional aid of air photos, the results of overland and beach traverses could be plotted directly on to them. Field work was followed by examination of the rock specimens, interpretation of field results, and intensive interpretation of the aerial photographs, consuming most of the time available for research from September 1957 till now. During this time I had valuable help with some of the petrological and structural problems from Drs. T. G. Vallance, H. Wilshire, G. H. Packham and F. G. Larmine, my colleagues in the Department of Geology.

This report aims to give an interim picture of the regional geology of Choiseul. It should be accurate in

its broader features but is likely to be wrong in some of the detail. It is divided as follows:

- A. General Description of Choiseul;
- B. Stratigraphy;
- C. Structure;
- D. Palaeontology;
- E. Economic Aspects.

Some parts are in greater detail than others. Thus the palaeontology is described very briefly, mainly because the important fossils are the subject of another paper; the central-east part of the island has not been ground-surveyed and so interpretation is less controlled and made less of than other parts of the island; the Kumboro Peak area, with its ultrabasic rocks, is being closely studied by Mr. Thompson, and so is largely left to him to describe. The accompanying map is no more definitive than the report. Few of the rock boundaries have been actually mapped for more than a few hundred yards at any one place; the greater parts of them are extrapolatory following study of aerial photographs. The map is an essay in regional interpretation, meant to give a generalised idea of the geological state of things and to act as a basis for future work.

A. General Description of Choiseul Island

Choiseul lies in the north-west of the British Solomon Islands Protectorate, just east of the Australian-administered island of Bougainville. It is intersected by Latitude 7° and Longitude 157°, and is shaped like a shallow reverse "S", the long axis trending approximately north-west to south-east. With its associated islands of Rob Roy and Wagina it is over 110 miles long and 25 miles wide at its central widest part, although in the west it is more often of the order of 15 miles wide and, in the east, 10 miles wide.

It is made up of schists which act as a basement for the other rocks, middle Tertiary calcareous and non-calcareous sediments, an abundance of lavas of Tertiary to subrecent age, and minor masses of dioritic and ultrabasic rocks. The structure is fault-dominated.

The coastline in the western half is relatively smooth, not indented, with straight and curved stretches of beach. The straight stretches may be in a zig-zag pattern due to the passing of faults disposed *en echelon* from land to sea; this sort of coast usually rises abruptly from a narrow beach or fringing reef. The curved stretches are nearly always associated with simple recent uplift of large fault blocks. Good anchorages are not frequent.

The eastern half is much more indented, especially the south-east coast, which has submerged along a great

system of straight-line faults. Some inlets penetrate two to three miles inland. One of them (Nggosele Passage) connects with a tide-scoured inlet from the other coast, and so gives rise to Rob Roy Island. This passage is then made up of a drowned valley connected almost at right-angles with the down-dropped part of a tilted fault block. It has been maintained, even deepened, by the tidal rips which come through it at speeds up to 12 knots and so have a most powerful scouring action. There are numbers of near-shore islands, some of them reef banks and vegetated fringing reefs, but many represent ridges which were part of the mainland before submergence. There are other features of submerged topography.

Wagina Island is a low flat island, a good example of a stabilised sand cay, now completely vegetated, with beach ramparts and a broad fringing reef. It is but one of the many examples Choiseul offers to the student of reefs. Barrier "ribbon" reefs, barrier "platform" reefs, and fringing reefs are especially prominent types*. Most of the barrier reefs have a linear arrangement or have linear features which fit in with the pattern established for faults, joints and shatter zones (often referred to herein as "the lineament pattern"). Many fringing reefs can be seen growing along the seaward extension of faults, on the uplifted submarine scarp. The great lines of barrier reefs along the south-eastern coast equally obviously have their origin in some crustal structure so precisely linear as to indicate faults rather than swellings. West of Mount Matambe the reefs are an unusual fringing type which finger out to sea; they are thought to be growing on the seaward extensions of old ash or lava flows from the old cone of Mount Matambe.

Aerial photographs are invaluable for navigation around this coast; the Admiralty charts cannot be relied on when moving close in-shore.

The land surface has low overall relief. The highest point is Mt. Matambe, in the centre of the island, a presumably extinct volcano about 3,500 ft. high. The usual relief, however, is rarely more than 1,500 ft. at its highest. There are few other distinctive peaks: Kumboro Peak, 2,000 ft., a quiescent volcano at the eastern end; Mt. Ruravai, Mt. Sambi and Mt. Vasu are outstanding ridges bordering the south coast, all of them over 2,000 ft. The island is not evenly triangular in profile. In the west the higher ridges tend to border the coasts with broad lowlands between. In the centre the surface falls evenly away from Mt. Matambe to the north, but to the south the profile fall-away is interrupted by high coastal ridges. In the east the profile tends to be wedge-shaped, the highest parts bordering the north coast.

The land surface reflects fairly closely the country rocks and the geological structure. The major topographic features are the expressions of block faulting, the minor ones reflect the nature of the country rock. Thus the recently elevated limestone reef complexes (e.g. that north of Nukiki village) are fault-defined blocks which appear to have been bodily lifted over 1,000 ft. at their

furthest extension inland. Their appearance is highly distinctive. They are in an early stage of erosion, and show karst topography with flat-top pinnacles and sink-holes with vertical sides, usually not communicating with each other. There is no surface drainage. This sort of country is impenetrable for the most part. In aerial photographs it has the familiar pustulose pattern. The calcareous sediments show a milder form of karst topography; the more steeply dipping beds may show sharp strike ridges combined with long dip slopes speckled with choked-up sinkholes but with few pinnacles. The vegetation is not so very dense, and the main difficulty in traversing such sediments is caused by the large areas without surface water.

The non-calcareous sediments and pyroclastics have a subdued relief due to their relative ease of erosion; for the same reason they are intensely dissected and cut about, with narrow shallow valleys separating razor-back ridges.

The lava country gives high relief. It is made up of saw-tooth ridges, wide valleys, with preferred orientation parallel to the dominant fault pattern—that is, in two sets trending to the north-west and to the west, respectively. Block faulting is very evident, many of the larger ridges being fault-defined. The schist country tends to have more rounded ridges, often serrated along their longitudinal profiles, parallel to the schist foliation; it is often more cut about than is the lava country. The ultrabasic rocks yield a characteristic topography, with rounded and hump-backed hills, open drainage, and a light jungle mantle.

The jungle cover is thickest on the non-calcareous rocks. It is reasonably open and only on the highest ridges, or in isolated pockets, is there much vine or bamboo infestation. A noteworthy feature is the presence of large mangrove swamps, especially prevalent over the eastern coast, in the inlets and at river mouths. Peculiarly enough, the land borders of these swamps often show rims of good outcrops. This may be due to the etching qualities of the mangrove-polluted water.

The climate is tropical-equatorial, but the sea, never more than 12 miles from any point, has a moderating influence. It is only in the low-lying densely-vegetated swampy areas that conditions become unbearably oppressive. The island is orientated more or less in line with the monsoonal winds so that there are no well-defined "wet" and "dry" seasons. My field season was in the months of the south-east wind, that is, in the supposed "dry"; it is difficult to imagine that more rain could fall during the "wet" than fell then. There are no official records for rainfall or other climatic statistics. Local opinion confirms my experience, so that future field workers must be prepared to cope with heavy rains throughout much of every second day. Apart from the personal discomfort, this is important if one is aware that many of the rivers are liable to sudden and heavy flooding. Because of the island's orientation to the winds there is no good weather coast; particularly in the west, selection of an anchorage will depend whether it is a south-east or north-west wind blowing, or likely to blow, at the time.

* The terminology follows Fairbridge, 1950.

The drainage patterns are complicated and cannot be readily described by conventional terminology. The most obvious thing about the rivers is the extent to which their courses are controlled by faulting or jointing. This is especially true wherever the beds are in lavas and schists. In the western third the main drainage is effected by the Vasu river and its tributaries, debouching on the north-west coast. The Vasu is over 30 miles long and drains an area of approximately 200 square miles.

The greater part of this system flows in a series of structurally controlled bends from south-east to north-west. Both north- and south-flowing tributaries wriggle their way through a tight succession of bends, the long arms of which run south-east to north-west; their headwaters often have long straight secondary tributaries, again oriented south-east to north-west. The Kolombangara River system, the second largest, has a similar pattern; it flows out on the southern coast. The smaller rivers which drain the high ridges bordering much of the coast have an open trellis-type pattern, again with many straight stretches parallel to the lineament pattern.

At the western end of the island and at other places where the rivers are bedded in clastic sediments, the pattern is more of a dendritic type: sudden changes in course, pronounced straight stretches, are usually associated with faulting. As already mentioned, the limestone country has no surface drainage. The pinnacle pattern may be regular due to the line-up of sinkholes along the strike directions or along faults.

The rivers draining Mt. Matambe are directly consequent but midway along their courses become controlled by basement faulting. In the area east of Mt. Matambe the drainage is of a more open trellis type, although the country is made up of a complex of lavas and metamorphic rocks which are heavily faulted and show distinct lineament patterns. Variation in rock type obviously plays a part in determining the drainage, but not enough is known about the distribution of the various rocks to be able to analyse this effect.

As survey paths the rivers of Choiseul are rather disappointing. Most of them are very immature, and rapids and waterfalls are very frequently met with; and as has been mentioned, they seem to be in flood or near-flood condition most of the time. Therefore, one has to use native tracks, on which fresh outcrops are comparatively rare, more than one would wish.

B. Stratigraphy

The rocks of Choiseul can be described under three headings. First, the basement schists; second, the intrusive and extrusive lavas of supposedly lower Tertiary age; and third, the sediments and volcanics of Miocene to Recent age.

They have been divided into the following units, given in order of increasing age:

11. Undifferentiated sediments, probably volcanic.
10. The Kumboro Volcanics.
9. Matambe Volcanics.
8. Uplifted subrecent limestones.

7. Pemba Siltstones.
6. Moli Formation.
5. Kamanga Grit.
4. Vasu Limestone.
3. Siruka Ultrabasics.
2. Vosa Lavas.
1. Choiseul Schists.

This division is based on reconnaissance mapping. Many units are therefore collective; for example, the Vosa Lavas comprise a "dump-box" unit to include the pre-Miocene lavas (although it will require a good deal of careful mapping to distinguish formations within this lava complex); again, the Kamanga Grit and the Moli Formation may prove to be facies variations within a single unit.

1. Choiseul Schists

This is the name given to a great mass of rocks, the oldest on the island, most of them regionally metamorphosed, usually foliated and schistose, which have many characteristics in common. However, they are not a homogeneous unit and with more work should be subdivided.

Preliminary study shows two main variants. One is finely foliated and schistose, the other a more granulitic rock, but both have much hornblende, and can be described as amphibolites. The former is the more common variety, a typical albite-epidote-amphibolite, very often with quartz, iron ores, clinozoisite and apatite. The main feldspar is albite. The hornblende is a bright green variety common to such rocks, occurring in streams of aggregated shreds and boat-shaped crystals. The crystals may be poikilitic to grains of apatite, epidote and clinozoisite. The quartz is in veins which are often deformed to show microstructures such as drag folds and faults and shears. The epidote occurs mainly as veinlets made up of tiny shapeless grains and as granular aggregates. The grains of iron ore (usually magnetite) are dragged out in strings.

The granulite amphibolite may range in fabric from one schistose or sub-schistose, with 'eyes' of large sub-hedral hornblende crystals, to one which is thoroughly mashed-up and granulose. The majority of thin sections show something in between. The more crushed examples are found near intrusive lavas and may be secondary. Indeed, chemical alteration due to younger lavas is a feature of the schists; for example, wherever propylitized andesite lavas are close by, the schists are striped over small areas of outcrop by bands composed of a mush of clouded feldspar, epidote and clinozoisite.

All the specimens studied are too much altered to give positive information of the identity of these rocks before metamorphism. By and large, their compositions are such that they might well have originated from lavas such as dolerites or basic andesites, and perhaps pyroclastics of similar compositions.

The major structure of the schists cannot be described here. Although the dip, strike and intensity of the schist foliation was taken at most outcrops and any other microstructures noted which might help in arriving at the major

structure, there were not enough observations and they are too scattered to give valid evidence. The main foliation directions have strikes of 140° and $170-180^{\circ}$ respectively. The planes are always steeply dipping, from 45° to vertical. All that can be said with certainty just now is that there is a great bulk of these rocks and that they act as the basement for all other rocks which have surface outcrops.

The schists outcrop cover a large area at many localities over the length of the island, but most commonly in the east and centre. Individual outcrop areas may vary from river bed exposures to areas of several square miles. The large areas are fault-uplifted blocks, and the uplift may be such that both ridges and valleys will be composed of schist, e.g. south of Kumboro Peak, around Mt. Vasu and along the lower Kolombangara valley. The exposures revealed by cutting down of rivers are more frequent than might be suspected. In areas where they are exposed in the river valleys the ridges are capped or composed of younger rocks, e.g. east of Bubukuana village on the north-west coast. Such exposures do not show in aerial photographs, and it is likely that the area of basement exposed is even larger than indicated on the accompanying map.

2. The Vosa Lavas

This is a collective name used provisionally to describe a complex of lava types which were intruded into and extruded over the Choiseul schists, and which act as bedrock for the sediments described later on.

The complex consists of three main lava types: andesites, basalts and dolerites, with many variations within each type. Andesites appear to make up the bulk of the lavas, probably as flows, although this is by no means certain; only a few outcrops showed definite flow characteristics. The basalts occur very often as pillow lavas. The dolerites occur as small dykes intrusive into schists, andesites and basalts; and also as larger bodies the forms of which are uncertain; they may be sills or laccoliths.

The name is taken from Vosa village, opposite Zinoa Island, on the south-west coast. Beach sections near this village show a variety of lava types (a variety wide enough to be in keeping with the very mixed assemblage of rocks lumped under the name of Vosa Lavas), so that when they are mapped and subdivided, the name can then be restricted to a particular lava or group of lavas which outcrop near the village.

Proceeding east to west from a point about $2\frac{1}{2}$ miles east of Vosa, the beach section shows amphibolite schists with occasional small ribbon dykes of basalt, sub-parallel in strike to one or other of the main joint directions (north to south, and north-west to south-east), but not to the foliation direction (west to east). Then come massive fine-grained black lavas which vary irregularly in composition from outcrop to outcrop. The contact with the schists is obscured. Some outcrops are of olivine and augite basalt, others are doleritic, yet others are made up of andesite, usually propylitized. The area is faulted and shattered so that only fault contacts were seen.

Just west of Vosa village pillow lavas outcrop, although the outcrops are slab-like and do not show the pillows to best effect. They are composed of an olivine-free basalt, often with phenocrysts of labradorite and rare augite set in an altered groundmass in which iron ores are abundant. The phenocrysts are frequently altered: the felspar is albitised, the augite corroded and converted to a greenish chloritic clay. The groundmass is obscure; it consists of altered felspar (only the relic forms of the shards remaining), carbonate, zeolitic material, and green clay. There is a good deal of secondary fibrous zeolite filling veins and cavities. This general description is typical of pillow lavas studied from other localities on Choiseul.

After the pillow lavas there are repeated outcrops of andesites, a few of pillow lavas, and then the lavas give way for a few miles to sediments (contact obscured). There is another stretch of lavas near Kuku village, mainly pillow lavas; but from there on, past Moli island and around the western end of Choiseul, along the northern shore to Bubukuana village, the coast is free of them. They occur inland over this western third of the island, however, in the more deeply cut rivers of the south and along the middle reaches of the Vasu River. In this area the lava outcrops are most often composed of altered, propylitized andesite. The predominant mafic mineral is a green hornblende in platy crystals optically surrounding a turbid plagioclase (labradorite) which shows undulose extinction; iron ores are abundant, especially magnetite. Zeolite veins are common and include the variety laumontite. Depending on the degree of propylitization, there are minor amounts of epidote, clinozoisite, and chloritic green material, and patches of carbonate material. Fine-grained basalts and dolerites are present, but do not seem to be as common as andesite.

These same lavas are the pebble constituents in a grey to silver-white "puddingstone" (as seen in water-worn outcrop) which is found overlying the lavas. It is a very distinctive rock and may prove to be a marker bed for western Choiseul. The pebbles are usually fairly rounded, 2 in. to 3 in. in largest dimension, not as prominent as the tough and hard matrix. Indeed, at first sight this rock appears to be composed of a surprising combination—agglomeratic lava pebbles set in a welded tuff or ignimbrite. It is thought to be a single formation, but it is certainly possible that detailed work could show the existence of several "puddingstones". Even so, their presence would indicate the top of the Vosa Lavas in this area.

East of a line joining Bubukuana and Vosa villages, both inland and on the beach, lavas supplant sediments as the dominant surface rocks. This is especially so along the northern coast. From Bubukuana, east to Nanano Island, fault-defined lava ridges run *en echelon* into the sea, oriented north-west to south-east and so diagonal to the general west-east trend of the coast. Many points and spurs jut out to sea and outcrops are good. Basaltic pillow lavas, basalts, andesites and dolerites occur. The andesites are most variable: to instance but one good example, at a very large outcrop one mile east of Bubu-

kuano, west of the mouth of a river, the rock faces show clearly segregations of more basic material and a wide range of textural changes. The coarser-grained segregations appear as tongues, pseudo-intrusive into the finer lava mass of more typical andesite. Small specimens of this material closely resemble ordinary diorite; the basic and coarser-grained specimens may even appear gabbro-like in hand-specimen or small obscured outcrop. Variation in composition is mainly due to the effects of propylitization and to changes in amount and nature of the principal mafic minerals.

The basalts are mostly in the form of pillow lavas, similar to those of the south coast. They are intruded by both basalt and dolerite ribbon dykes. The pillows retain something of their shape even under jungle weathering, so that they have been recognised at several localities inland, where other lavas have been reduced to featureless rubble. Nevertheless, the beach outcrops gave conflicting and confusing evidence about their structure; indeed, at only one locality was it possible to see that the pillows had a general surface inclined at a definite angle. The field structures of the andesites are extremely difficult to determine. Even in large outcrops one is often unable to decide upon the nature of the rock body, whether flow, sill or discordant intrusion. To keep perspective, it might be mentioned that in this sort of country a "large" outcrop might be a sea cliff exposure of a few square yards in area.

Towards the centre of the island the lavas become less dominant. Miocene sediments cap many of the ridges; greatly uplifted fault blocks are composed entirely of Choiseul schists. All of these rocks in turn give way to the blanket cover of volcanic rocks given out by the cone of Mt. Matambe, which cover the greater part of central Choiseul. The boundaries between these volcanics and the older Miocene tuffaceous sediments and the lavas of the Vosa complex are shadowy and may be difficult to define even after detailed mapping. As shown on the accompanying map they are no more than provisional and indicative.

In eastern Choiseul lavas are exposed over most of the area from Mt. Matambe to Ruravai Inlet. The older lavas in this area have been examined only superficially. Mr. Grover has sampled them at various points along the northern coast; Mr. Pudsey-Dawson collected on two cross-island journeys from Posarai to Vure to Ruravai villages, and I examined them along the south coast. The samples include augite-hypersthene basalts, usually olivine-free, hornblende andesites, augite dolerites and granulitic coarse-grained basic dolerites. Pillow lavas appear to be less common than in the west. There is just as wide a variation in composition and texture shown by these lavas as by those described. The coarse dolerites appear to be very common, especially along the north coast, and as seen in the field, might well be taken for rather basic diorites, indicating the possible presence of a pluton. However, similar "diorites" and "micro-diorites" have already been described which are actually segregations from large bodies of lava; the existence of a plutonic mass on Choiseul has yet to be established.

The specimen nearest to a typical diorite is a hornblende-augite-enstatite rock, very coarse grained, with a little quartz, obtained from Banaroi River, southern Choiseul. The outcrop is associated with the Choiseul Schists, but its field relationship to the schists and its field structure are unknown. The stratigraphy within the Vosa Lavas and the precise distribution of the various types are not well known, and may never be known; the jungle cover and deep weathering prohibit the detailed surveying and sample collecting which would be necessary to unravel this sort of complex. Andesites appear to predominate greatly over most of the succession. The pillow lavas apparently occur high up. They have been seen to lie directly and unconformably beneath the Miocene sediments at a few outcrops, and at many other localities they are in close proximity to them, the contacts either obscured or faulted. There is nothing to suggest that the pillow lavas were extruded in a single lava episode; there may have been several extensions, probably within a fairly short time period. On present evidence they cannot be related to any controlling feature. The coarser-grained andesites and dolerites may be basal in the lava sequence, as they have always been found, up till now, in close association with the Choiseul Schists.

The structural picture is very vague; the few structural features observed in outcrop indicated flow surfaces inclined at low angles, less than 10° . In aerial photograph many of the lava ridges show general north-east dips of up to 20° . Some, if not all, of these are tilted fault blocks, for example, the lava ridges between Bubukuano and Kolo; similar isolated tilt blocks occur wherever lavas outcrop extensively. It amounts to this, therefore, that the grander structural features of the Vosa Lavas are unknown. The thickness of the Lavas is greater than 1,200 ft., but by how much is unknown.

The bulk of the Vosa Lavas were in place before the Middle Miocene. There is no sign of a lava body in the Moli formation of immediately post-Middle Miocene age. The underlying Middle Miocene sediments include basal grits which, at a few exposures, appear to have suffered some baking and alteration which may have been due to lava intrusion (see also mention of the "pudding-stone" above). Below these Middle Miocene sediments there are no sediments and no evidence of a major erosional hiatus older than the Miocene. Contact with the underlying Choiseul Schists appears to be unconformable.

On negative evidence, therefore, it can be thought that the Vosa Lavas represent a well-defined period of vulcanism, of many short-separated episodes, which occurred prior to the Middle Miocene. It probably did not begin very much earlier than this: in the Middle or Upper Oligocene would be a reasonable speculation.

3. *Siruka Ultrabasics*

These are being studied and described by Mr. Thompson, geologist with the Geological Survey Department, and were named by him. They are mentioned only to complete the stratigraphic succession described herein.

The Siruka Ultrabasics are a complex made up largely of serpentinitised peridotites but including some with asbestos fibre and also less serpentinitised enstatite peridotites. Antigorite and chrysotile are the main serpentine minerals, present as pseudomorphs after amphibole, olivine and enstatite, and also as confusedly scaly and fibrous aggregates. The enstatite rocks weather brown to brownish-green with a saccharoidal texture. They frequently outcrop in layers or selvages sticking out from clayey hillsides, and, at first appearance, resemble a clastic sediment bed. The serpentinitised peridotites occur in shattered shapeless masses, very often with a greenish-black to black waxy finish. Both types are usually veined with black and green serpentine and green epidote.

The characteristic hump-backed hills, reduced drainage, and sparse jungle cover of areas of ultrabasics in tropical regions were first noticed in a preliminary study of the aerial photographs of Choiseul. Specimens were first collected on the southern coast of Rob Roy Island; indeed, this island seems largely made up of ultrabasics overlain by tuffs, probably derived from Kumboro Peak volcano. Their largest area of outcrop, however, is to the west and south-west of Kumboro, as far as Ruravai Inlet. Here they are associated with lavas, some of which came from Kumboro, and especially, with large inliers of the Choiseul Schists. It is probable that the presence of these large inliers in the ultrabasics was brought about as much by block faulting as by vagaries in emplacement. Only fault contacts were seen between ultrabasics, schists and lavas, excluding dykes.

The structure of the ultrabasics is rather peculiar. In the field and in the aerial photographs their outstanding characteristic is the way in which they appear to be flat-lying, perhaps 1,000 ft. thick, and, stratigraphically, very little removed from the schists. Many of the schist exposures appear in windows which have resulted from erosion, and on Rob Roy island parts of the lines of outcrop are very nearly parallel to topographic contours. Their gross form could be explained by supposing them to be the remains of a very low angle thrust-sheet which has been sundered by faulting, especially by the great faults to the south. However, this question of their field structure is obviously bound up with the wider problem of their genesis and emplacement; this is at present occupying Mr. Thompson as part of his regional study of the ultrabasic rocks of the British Solomons.

Their age is unknown. They certainly did not share the metamorphism which produced the Choiseul Schists, and so are younger than these. Some of the associated lavas may be representatives of the Vosa Lavas (at one locality, caught up with schist in a small fault block, an andesitic lava was seen, which had been slightly serpentinitised). It may be that the ultrabasics are younger than the Vosa Lavas, but if so, and if the extent of the Vosa Lavas in this area was as great as elsewhere, there must have been a considerable period of erosion before the intrusion of the ultrabasics. They have not been found in contact with sediments of which the age is known. It cannot be even said that they are definitely pre-Miocene.

4. Mount Vasu Limestone

This is an impure, poorly-bedded calcarenite containing rock and mineral fragments. It has been found *in situ* at only one locality, one mile east of Mr. Vasu, in a stream which joins a west-flowing tributary of the Kolumbangara River. Boulders of the same material have been found to the west in the lower country just north of Sangigai village; aerial photographs also show small outcrops of limestone north of Mt. Vasu, and these may be the same limestone. It has not been found in its expected place on other traverses, and so it may well be a small deposit, possibly a large lens or set of lenses within the Kamanga Grit, that is, a member of this formation. (See next section.)

This limestone is a creamy white, blocky, biostromal calcarenite, poorly bedded, with a hackly fracture, and containing rounded schist pebbles. It is often cavity-ridden. The cement is a cloudy (argillaceous?) calcite. The terrigenous material may amount to 15% of the whole. It consists mostly of schist fragments, derived from the Choiseul Schists, and worn crystals of amphibole, iron-stained feldspar, iron ores and occasionally cherty fragments. The absence of lava fragments is not used as evidence that the Vosa Lavas followed deposition of the Mount Vasu Limestone, but rather that the lavas were unevenly distributed: elsewhere, outcrops of the Kamanga Grit, of the same age as the limestone, overlie lavas.

The organic material consists of small foraminifera (benthonic and pelagic); larger foraminifera including *Nephrolepidina* sp., a lepidocyclina with features of both eulepidine and trybliolepidine types, *Cyclotypeus* sp., *Operculinella* sp., and *Gypsina* sp.; abundant *Lithothamnium*-species and other algae, echinoid spines, rare coral fragments, and shell fragments. The organic material is always 70% or more of the rock.

The grain size varies from several centimetres (schist pebbles) to one centimetre (schist and algal fragments) to less than 0.1 of a millimetre, but the bulk of the rock consists of 1- to 3-millimetre grains. The cement may make up 20% of the total.

The thickness and structure are unknown. At the Mt. Vasu locality it appeared as a pocket presumably with faulted boundaries. It might be a discrete body lying directly on the schist basement or a lens at the base of the Kamanga Grit. The age of the limestone is considered to be lower Middle Miocene, that is, about Burdigalian on the European scale.

5. Kamanga Grit

Near the mouth of the Kamanga River and along the coast east and west for several miles there are outcrops of a coarse-grained clastic containing a species of a lepidocycline genus difficult to distinguish from either *Eulepidina* or *Trybliolepidina*, the same as that in the Mt. Vasu Limestone.

This sediment is called a "grit", although within it there are occasional layers of lithic sandstone and of shale. The bulk of the rock is made up of poorly-bedded

grits containing angular and subangular fragments of lava, andesitic and basaltic, rare pieces of tuffaceous mudstone, and rare shell fragments. The matrix is tuffaceous, a fine-grained re-worked crystal tuff, with a clayey or calcitic clay cement. The fragments may make up 70% of a hand specimen. The bulk of them are over two millimetres; few of them are larger than one centimetre. Some parts, not otherwise distinctive, have no calcite and lack fossils completely. Generally there is a good deal of variation in composition, grain size and other textural features, even over the face of an outcrop a few yards square. Usually it requires a thin-section or an acid test to determine whether or not calcite is present.

Because of this variation, the Kamanga Grit is thought to include other grits, not directly connected with the outcrops at the Kamanga River, including those west of Lukuvuru village, grit-veneers on lava ridges inland, and those showing a discordant contact with underlying Vosa Lavas at Sangigai Point (on the south coast) and in a U-shaped bay two miles east of Saravore point and Banera village (on the north coast). Some of the thin layers covering lava ridges about 10 miles west of Mt. Matambe have blobs of finer-grained sediment resting on them. These are thought to be parts of the Moli Formation. However, no real contact with the Moli Formation has been seen so far, and it is on aerial photograph interpretation and on regional evidence that this formation is considered to overlie the Kamanga Grit.

Nearer Mt. Matambe clastic sediments on the lavas show up in the aerial photographs; it is very difficult to decide whether these superficially placed sediments are Kamanga Grit, with, perhaps, Moli Formation sediments, or whether they are remnants of ash deposits from the cone of Mt. Matambe. The position of boundaries on the map delimiting Moli Formation, Kamanga Grit and the more recent lavas and volcanic clastics (the Matambe Volcanics) should be accepted as merely provisional. Very detailed surveys will be required to sort out and define these boundaries.

The greatest measured thickness of Kamanga Grit is nearly 100 ft. This is perhaps doubled over much of its area of outcrop. The structure is complicated by faulting but the formation appears to be a broad anticlinal warp, very much broken by block faulting, the limbs dipping at small angles (approximately 5°) to the south-west and north-east respectively and plunging gradually to the west so that the outcrops disappear under the Moli Formation and the Pemba Siltstones.

The presence of the *Lepidocyclina*-species mentioned above indicates that the formation was laid down in lower Middle Miocene time.

6. Moli Formation

This name is applied to a mass of clastic sediments which outcrop at many places over most of western Choiseul and which show great uniformity in general appearance wherever they occur in large outcrop. They can be studied well on Moli Island and on the mainland across the narrow Moli Channel.

The largest areas of continual outcrop are found in the

south, with excellent exposures along the coast, but uplifted blocks bring these sediments to the surface at scattered localities all over western Choiseul, for example at Ririo and the Kamanga River on the north coast, and along the middle reaches of the Vasu River in the centre. It is possible that they occur in eastern Choiseul at Ruravai Mission. At this and many other localities to the west there appear to be outcrops of the Moli Formation, but a direct connection with the western outcrops has not been found. Such outcrops are included in the areas marked on the map as "Undifferentiated Sediments". Since there is also the possibility of confusing them with much younger volcanic sediments derived from still extant cones, e.g. Matambe and Kumboro, the presence of the Moli Formation in eastern Choiseul is queried.

The most outstanding characteristic of these sediments is their banding. The bands vary in thickness from less than a centimetre to nearly 30 centimetres, but five to 10 centimetres is more usual. The bands are emphasised by strong colour contrasts, varying from grey-white to buff to black, and by differences in grain size, composition, and intraformational sedimentary structures. They are irregular rather than rhythmic, but irregular within narrow limits so that outcrops of Moli Clastics have very similar and distinctive features; a beach section on the north coast, for example at Ririo, is mirrored by any one of a number of sections along the south coast, over 15 miles away. The fine-grained bands can be classed as clayey siltstones. They are usually pale-coloured and consist of clay, with grains of feldspar, amphibole, epidote, occasional calcite and rare small foraminifera. The coarser-grained bands tend to be dark in colour and vary in grain size from fine-grained lithic sandstones to coarse grits consisting largely of lava fragments, pumiceous material and clay matrix. The sandstones have similar compositions, but the proportion of mineral fragments and crystals is higher; they are either tuffs or re-worked tuffs. In some of the crystal tuffs the ferromagnesian minerals may amount to 80% of the whole, amphiboles predominating. In other bands of crystal tuffs the sorting may result in a concentration of feldspar. The lava fragments are usually andesitic, but may also consist of basalts and dolerites.

The calcite content varies greatly; some bands lack it altogether, others contain as much as 30% of the whole. It usually takes the form of calcitic clay, but may appear as a crystalline cement following solution and precipitation—probably the result of diagenesis. The foraminifera are sporadic and rare, and include both benthonic and pelagic forms; they do not appear to have been derived. The occasional shell fragments cannot be identified. The organic remains do little more than indicate a marine environment of deposition.

The sedimentary structures occur haphazardly. Wherever they occur they show up beautifully because of marked colour contrast. A small cliff face of a few yards square may show the following features: graded bedding, micro-slumping, mudcracks, intraformational brecciation, scour and fill, ripple mark, small-scale cross-

bedding, compaction-faulting and minor faulting with throws of up to six inches. A detailed study of the Moli Formation, if only for the sake of these structures, would be a most rewarding piece of work.

The more obvious characteristics of the Moli Formation indicate its rapid accumulation from a provenance undergoing fluctuations in physiography, and subject to intense if intermittent vulcanism. The banding especially represents a succession of sedimentary profiles, each band heralding rather different conditions of sedimentation than had existed before. The variations were irregular and shifted laterally, but similar conditions recurred again and again over small areas in a rhythmic, if not cyclic, way. The area of deposition or, rather, the environment of deposition is difficult to judge; from the limited evidence available, a deep shelf environment is suggested.

The Moli Formation is at least 500 ft. thick. This is a conservative figure based on a small, apparently unfaulted, section. Faulting is so common that larger sections included faults the components of which are unknown. The regional picture of the formation would suggest a thickness of at least 1,000 ft.

The regional structure is that of a wedge thickening west-north-west, west, and west-south-west from a point a little west of the centre of the island, with a general dip of about 5–10°. The value of the dip and strike measurements on the ground is dubious because of the pronounced faulting; many of them are anomalous and reflect fault-block tilting.

The exact age of the formation is unknown. No diagnostic foraminifera have been found. There is no apparent depositional gap, however, between it and the underlying Kamanga Grit, which is of Middle Miocene age. The formation was probably laid down during upper Middle Miocene, perhaps including part of Upper Miocene time.

7. Pemba Siltstones

In western Choiseul, and especially west of the lower reaches of the Vasu River, the Moli Formation is overlain by a mass of calcareous siltstones. The name given to them is taken from the Pemba River, which shows excellent exposures of these sediments.

In the Pemba section their colour varies from cream to buff-yellow to brown and reddish-brown, but cream is predominant. They are usually indistinctly bedded but often banded, in bands two to four centimetres thick, due to sudden changes in texture. They are consolidated, occasionally friable, and show an uneven blocky sub-conchoidal fracture. Occasional bands show graded bedding but by and large they lack minor sedimentary features. The banding seems to be defined by slight sudden changes in grain size. This varies between grain distinctly recognisable, grains less than 1/20th mm., to aggregates of flocculated clay. The clay forms about 40% of the whole, so that on the Wentworth scale this sediment might be termed a clayey siltstone. The larger grains consist of rare pelagic foraminifera, especially

Globigerina spp. and *Orbulina universa* d'Orbigny, quartz, euhedral and subhedral crystals of hornblende and feldspar, iron ores, pieces of organic calcite, and indeterminate rock and mineral grains. The identifiable part of the rock may amount to 30%. A lot of the clay must be calcitic, as the residue insoluble in hydrochloric acid rarely exceeds 30%.

This description fits the Pemba Siltstones as they occur over the western half of their outcrop area. They are sediments which rather resemble certain types of lagoonal sludge which make up the sea bed between fringing and barrier reef on the coast of Choiseul today. Towards the Vasu River, however, they appear to become coarser grained, especially higher in the sequence. The grain size is now in the very fine to fine-grained sandstone grade, and contains very much more organic material, particularly foraminifera, including benthonic species. It should perhaps be termed an argillaceous fine-grained calcarenite. The mineral content is higher. The mineral grains are less well preserved and the iron ores are partially oxidised, which gives the sediments brownish and reddish tints. The rock fragments are usually weathered fine-grained lavas. The cement is calcite, part crystalline and part clay. The bedding is still poorly defined.

The above change appears to be consistent and may represent a west-to-east facies change, indicating an eastern provenance for the Pemba Siltstones; more work is necessary to establish this possibility.

The contact with the underlying Moli Formation (observed at only a few localities) is marked by a thin bed—probably less than 30 ft. thick—of intraformational breccia or low-grade conglomerate. It is made up of angular fragments of calcareous siltstone, calcarenite with varying amounts of cement, poorly calcareous well-bedded mudstone and coarser clastics (both of these probably re-worked Moli Formation), and of fragments of andesitic lava. This mixture is well cemented in part but is often quite friable. Only the lava constituent is at all rounded. The size of the pebbles or fragments varies from 2 mm. to several centimetres, but only the lava pebbles are over 2 cm. The matrix is a calcareous clay.

This may be a distinct formation, but not enough is known about it to warrant giving it a formal name. Although it has been observed over a limited area only, it is important because it indicates a period of non-deposition following the laying down of the Moli Formation: it might also prove to be a marker bed.

The thickness and structure of the Pemba Siltstones are difficult to calculate because of the intensive faulting over the outcrop area. Dips from outcrop and aerial photographs indicate a regional dip of 5–15° in a south-westerly direction over the southern half of the outcrop area; in the north they tend to have higher values. The structure suggested is an asymmetric basin broadening out to the south-west. Sections uninterrupted by faulting give thicknesses not much more than a few hundred feet, but the regional picture suggests a much greater thickness, possibly of the order of 2,000 ft. The age of these sediments is probably Pliocene, an opinion based on their

stratigraphic position, for they do not contain, apparently, any fossils definitely indicative of this time.

8. *Uplifted Subrecent Limestones.*

These comprise at least four large areas of recently elevated reef limestones. From west to east along the southern coast they occur north of Nukiki village (the Nukiki Limestone); north of Tasure village just west of Luti village (Tasure Limestone); at Bavuti anchorage just east of Luti Bay (Bavuti Limestone); and at Sambi Point (Sambi Limestone). The Nukiki and Tasure Limestones are the largest and each covers an area of about 40 square miles. All of them appear as tilted unterraced slabs, up to 200 ft. thick, rising from the coast to nearly 1,100 ft. for the Nukiki Limestone and to nearly 1,000 ft. for the other three slabs of limestones (estimates taken from aerial photographs). In shape they appear as great embayments into the island. They have been eroded but are still at a youthful stage of karst topography. Their boundaries are faulted. The Nukiki Limestone has thin outliers removed from the main mass by a few miles.

They are outstanding in the aerial photographs, the sinkholes separate entities but arranged at the margins in lines curving parallel to the margins and hence thought to represent depositional strike lines. The pinnacles are often flat-topped and seen from a distance lie on a line running uninterrupted (except where the formation has been faulted) from sea-level to the highest point. They appear to have been suddenly and bodily uplifted as a veneer on tilted fault blocks.

They have not been properly sampled (a traverse one mile into the Nukiki Limestone was a major undertaking) but on the samples collected they appear to be uplifted fringing reefs. The samples included foraminiferal calcarenites, microcoquinooid calcarenites with broken-down algal and coral fragments, porcellaneous sludgy limestone, and occasional masses of algae and coral. Parts are no more consolidated than present-day reef, other parts have been recrystallised into a massive form. The fauna is a modern one.

The shape of these limestone masses, the variation in the nature of the limestone, their appearance in aerial photograph, their strongly faulted boundaries, suggest that they are uplifted reef complexes; indeed, the Nukiki Limestone in aerial photograph still has all the characteristics one would expect in a freshly uplifted bay full of reefs and reef sediments.

They cannot be given a definite age of deposition. The fauna is decidedly modern but has no features which would rule against it being Pliocene. They are described as subrecent because they appear to merge into present-day reef and because they have retained their spatial identity in an area of many active faults.

9. *Matambe Volcanics*

This is a provisional name given to the lavas and tuffs which resulted from the activity of the old volcano, Mount Matambe, at 3,500 ft., the highest point on Choiseul. It is presumed quiescent, for though there appears to be no native tradition of any eruption, a hot

spring is found near the summit (Grover 1958). The cone is still quite recognisable, even though breached extensively by erosion. Lava flows centred on it can be seen in the aerial photographs as well as ash flows. These have provided platforms for reef growth on a part of the coast north of Mt. Matambe.

The area of distribution of lava and/or ash is very large. To the east there is an unbroken veneer of ash, and to the north and south an extensive but partial cover for at least 10 miles. To the west unmistakable Mt. Matambe material persists for only a few miles; then a belt of greatly uplifted country is met and the underlying older rocks have extensive outcrops. However, the boundaries of the area are quite indefinite; as soon as the surface continuity of lava or ash flow is broken it is impossible to distinguish them, in aerial photograph, from the very similar rocks of the Moli Formation or the Kamanga Grit, or the Vosa Lavas. It will be very difficult, in this sort of country, to do this even on the ground. Mr. Grover carried out a reconnaissance from Panggoi on the north coast, to Mt. Matambe, and thence to Luti Bay, and his account of the tuffaceous breccias, agglomerates and lavas would fit many samples from the above-mentioned units. The lavas are essentially andesitic, often porphyritic, and include fine-grained, rather basaltic types, both of which are common stock in the Vosa Lavas.

No definite age can be fixed for the Matambe Volcanics. A knowledge of the rate of reef growth in the region could be used to date the north-flowing ash and lava flows. The degree of erosion suffered by the latest ash flows suggests activity within the last few hundred years at the most. A Quaternary limit is suggested for the Matambe Volcanics as a whole, if only because the nearby Tasure Limestone has no tuff content in its lower part and it is almost certainly not older than Upper Pliocene.

10. *Kumboro Volcanics*

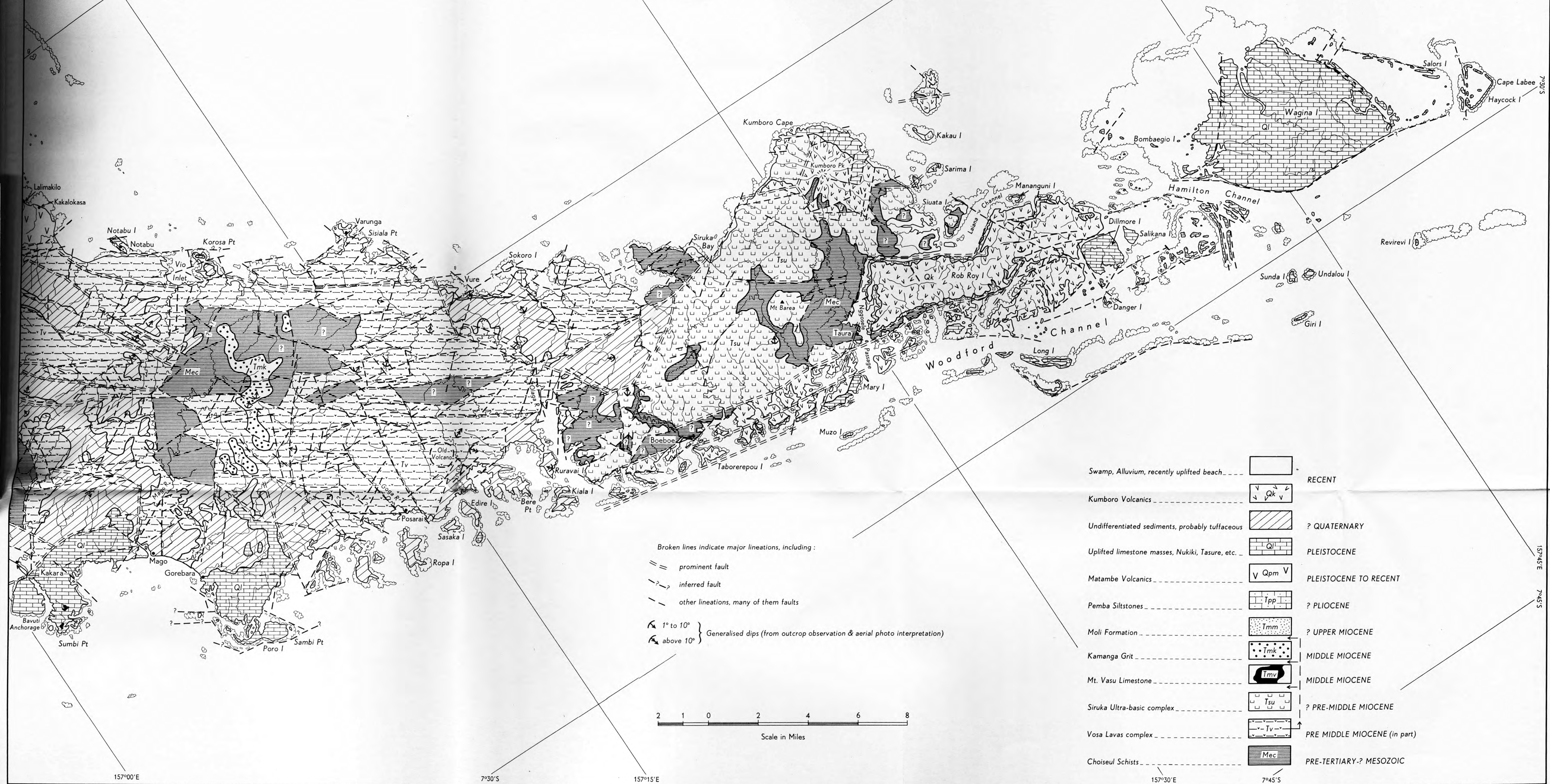
This is the name given to a mass of lavas and tuffs, in part basaltic and in part andesitic, which compose much of the area around Kumboro Peak, the volcano from which they came. They include andesitic tuffs which mantle Rob Roy Island and the southern part of the main island to the east of Ruravai Inlet.

The Kumboro area has been heavily faulted and blocks of Choiseul Schists and Siruka Ultrabasics have been uplifted and eroded and so limit the area of volcanics surrounding the actual cone. The dissection of the cone has even revealed schists* as part of the floor surrounding the neck of the volcano. The lavas, both flows and dykes, appear to be concentrated around the cone.

To the east an uplifted limestone rests on the lower flanks of the cone. Further examination of this limestone, which is probably of no older than late Quaternary age, might give information on the eruptive history of the volcano, especially if the limestone shows the position, proportion and type of an ash and/or lava constituent.

* According to Mr. Thompson by personal communication.

EASTERN CHOISEUL GEOLOGICAL SKETCH MAP



11. Undifferentiated Sediments

These are large areas of sediment, about which very little is known, west of the mass of Siruka Ultrabasics. They have been sampled at Ruravai Inlet and at a few other localities on the south coast near Ruravai, and proved to be banded tuffaceous fine-grained sandstones and shaley sandstones, probably re-worked, and often containing a few foraminifera which do not give any indication of their age. They may have been derived from Kumboro or Matambe or from a suspected old volcano, much eroded, to the west of Ruravai. On the other hand they may be older and be linked with the Moli Formation which they strongly resemble. There are other areas which appear to be the same in aerial photograph north of Sumbi and Sambi Points. These are quite large but have not been studied on the ground. These areas especially are so little known that it would be premature even to suggest a relationship with known volcanoes or to any older sedimentary formations.

C. Structural Considerations

Choiseul is a minor essay in earth fracture. It includes faults which are of such proportions that they might be termed taphrogenic, large shear fractures, normal and reverse faults, and small minor faults which demonstrate their activity by the way in which they are controlling the growth of fringing reefs. Faulting is the structural theme.

In aerial photograph the island is seamed by straight-line features (lineaments) which are most marked in "hardrock" areas and which result in a reticulate meshwork amounting to a definite pattern over large areas. The majority of these lineaments are confined in trend to the north-west and south-east quadrants of the compass. Within these quadrants one major set has a 90-100° strike, another major set has a 150-180° strike. The pattern is brought about by the intersection of these two sets.

Wherever they have been checked on the ground the lineaments have proved to be faults, large and small, as judged by the extent of their shatter zones. This does not exclude the contribution which joints make to the lineament pattern but more data than is at present available is needed to establish the nature of this contribution and its connection with the fault systems.

The faults show up best in the competent rocks, especially the Vosa Lavas and the Choiseul Schists. Their straight-line character supports the usual ground observation that they are high-angle, dipping at more than 50° and more often than not at 80° to vertical. They cannot be neatly divided, at present, into size categories. Some of them are of great size (in length and in the effects of displacement along them); indeed, parts of the coastline have been shaped, taphrogenically, by faults up to 20 or more miles long with relative vertical displacement of thousands of feet. Such are the set of three great faults which define the south-east coast of Choiseul. The majority, however, do not lend themselves to size division. Thus some major displacements, in areas of sediment, appear to have taken place along

broken lines of apparently minor faults; these are probably the interrupted surface expression in incompetent rock of a single large fault affecting the basement. Some ridges in the lavas, fault-defined, have been elevated not along a single fault plane but as the result of a riffling action along several fault planes. Such sharing of stress and its accommodation by a set of faults rather than by just one fault is a common feature of the Choiseul faults. In other faults the strike-slip (or "tear") component is predominant but only makes its presence obvious when, as on the north coast, a zig-zag beach line is produced by fault-defined ridges jutting, *en echelon*, out to sea, or when the courses of several rivers can be seen in aerial photograph to have undergone a similar lateral displacement of the place where the fault crosses them.

The less obvious lineaments seem to be small faults which often have a consequent relationship to the larger ones. Some large faults terminate in a horsetail cluster of small ones; a pair of large faults may have been connected by a diagonal set of close-packed smaller shear faults; other minor faults are strictly subsidiary to large faults, and arise from the differing response to secondary stress, following rupture, by closely associated rocks of different lithology. In areas of sediments, especially where the succession is thick, many minor faults cannot be related to any other structure.

The faulting has resulted in a jumble of fault blocks, elongated and with preferred orientation parallel to the lineament pattern. There is not enough evidence to produce a systematic, coherent description of the relationships between these blocks; they appear to have suffered haphazard jostling.

The structure is not complicated by any real folding. In the west the sediments lie in a broad basin open to the south-west. The eastern edge of this basin laps on to the higher country made up of lavas and schists. East of this again the sediments have a greater area of outcrop and appear to be anticlinally warped, falling away from the centre of the island at gentle angles to the north-east and south-west. The lavas show no recognisable folding.

The schist foliation is predominantly 140° in strike, dipping 35-50° south-west (an estimate based on less than 30 measurements). In some parts, however, there is a consistent 170-180° strike. There is not enough evidence to suggest any correlation between the schist foliation and the lineament pattern. It would be a very worthwhile job to carry out a systematic study of the schist foliation on Choiseul. There are large areas of schist exposed, they are comparatively accessible, and so it would not be too difficult to collect a controlled set of measurements of the foliation directions. In these respects Choiseul offers an opportunity, to an extent greater than the other islands of the Protectorate, to establish the regional structure of the basement rocks and hence the major primary tectonics of a large area of the Protectorate. In the absence of any large-scale geophysical investigations this would be an important contribution.

This information might assist in providing an explanation for the fault patterns. At present this can only be

guessed at : namely, that the patterns could have arisen by major crustal shearing in a roughly west-east direction, the north block moving east with relation to the south, accompanied by some north-east to south-west compression. But all this is very hypothetical.

In summary, Choiseul appears to have been elevated taphrogenically by major fractures which may or may not be associated with crustal warping. These fractures have resulted in the block-faulting of the basement rocks and differential movement of these blocks, movements which are still going on today. They probably began in Pliocene time.

D. Palaeontology

Foraminifera comprise the stratigraphically important fossil faunas of Choiseul. The most important members of this foraminiferal fauna are the orbitoid larger foraminifera. These occur in sporadic fashion in the Kamanga Grit but more frequently in the Vasu Limestone. They belong to the subgenera *Nephrolepidina* and a genus with characteristics in common with both *Trybliolepidina* and *Eulepidina*. These indicate an age for the containing sediments as Aquitanian to Burdigalian, probably Burdigalian; that is, lower Middle Miocene. The other larger foraminifera do not contradict this determination; they include *Cycloclypeus* cf. *postei* Tan, *Cycloclypeus* sp., *Operculinella* sp., *Gypsina* sp., *Amphistegina* sp., *Elphidium* sp., and large *Rotalia* spp. These larger foraminifera are being studied as part of an attempt to describe the Tertiary larger foraminifera of the Solomon Islands region.

The Kamanga Grit and Vasu Limestone are correlated with the Bonegi Limestone and Betilonga Limestone of Guadalcanal (see Coleman, 1957, 1959; Grover, 1955).

The smaller foraminifera are common in the Pemba Siltstones and uplifted limestone masses. They do not include diagnostic species which would settle whether or not the Pemba Siltstones are of upper Miocene or of Pliocene age. The fauna of the limestone (e.g. Nukiki Limestone) is decidedly modern in aspect but there is nothing in the fauna which would prohibit a Pliocene age for these also. The few small foraminifera found in specimens of the Moli Formation are quite useless for age determination.

Along with small foraminifera from other islands, the Choiseul fauna are the subject of another project.

E. Economic Aspects

The presence of ultrabasic rocks in the Kumboro area was first observed from the aerial photographs and later confirmed on the ground. They were not studied in any detail but were left to the attention of Mr. Thompson. He found some asbestos fibre, sufficient to justify a detailed survey (which he is at present doing) and nickeliferous laterites which are being test-bored.

So far as other metalliferous ores are concerned, Choiseul was rather a disappointment. Mineralisation seems to be restricted to occasional pyrite and other sulphides present as scattered small concentrations in the Vosa Lavas. Some of these appear to be syngenetic. Nothing comparable to the sulphide belts or "zones" such as characterise the igneous rocks of large areas of Guadalcanal were seen. Panning of river sands and gravels yielded not a trace of gold or other economically important heavy minerals. The black beach sands which are found on parts of the coast composed of lavas were examined and found to include a concentration of magnetite and some ilmenite. At the present time these are not of value. The mass of sediments in the west are not considered to offer much hope of petroleum accumulations. The succession is not encouraging, it is not thick by normal petroleum field standards, it lacks cover rocks, and it is structurally poor. No surface traces of petroleum were found, and none are rumoured beyond a few in swamps which proved to be iron oxide scums.

No potentially valuable clays or clayey ores (e.g. bauxite) were found.

This is not a very attractive picture. It is drawn, however, from the results of a reconnaissance survey and therefore the island should not be dismissed in too cavalier a fashion as a potential economic prospect, so far as its geology is concerned.

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REPORT No. 5
SOUTH MALAITA
GEOLOGICAL RECONNAISSANCES 1957-1958

By P. A. PUDSEY-DAWSON

Introduction

Field work occupied October and December of 1957, and October 1958. With the aid of aerial photographs, a geological map of South Malaita and Small Malaita was prepared. Joined to the map made by Mr. F. K. Rickwood in 1951*, this provides a first preliminary geological map of the whole island of Malaita.

During 1957 the field work was carried out in the Ari Ari District in the central and western parts of the area, which was mapped on a scale of 1 : 50,000. In 1958 crossings were made of Small Malaita from Rokera to Supaina and thence to Mobo Harbour and Ro'one ; and from Walande to Maka via Riverside Village. A coast trip was made by canoe in the Tarapaina area.

I. South Malaita Mainland

In south Malaita, though the Fiu Lavas have been recognised, the Fo'ondo Clastics have not been seen. In Maroupaina Bay very coarse dolerite lavas are found around the shoreline, being but textural variations of the normally ubiquitous finer-grained dolerites and basalts. The sediments overlying the lavas tend to merge into one another in the central portion of the island, as observed by Mr. Rickwood. Therefore they cannot be as clearly differentiated as in the north. Apparently conformable with the underlying volcanics, the greenish-blue and greenish-yellow Kware Mudstones are of variable thickness, but seldom in excess of 200 ft. They show good bedding and contain characteristic pyrite nodules.

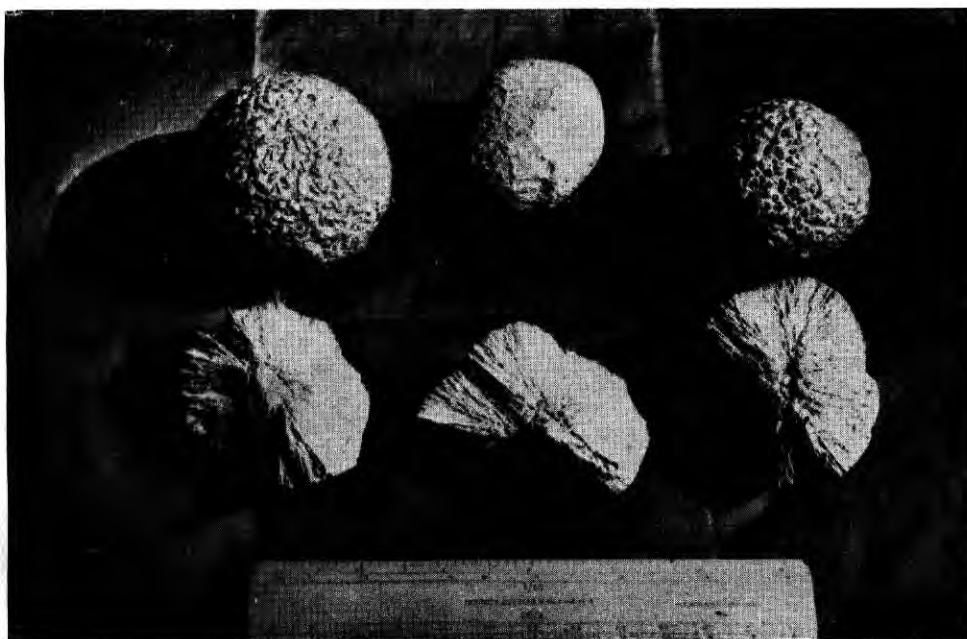


PLATE III

Pyrite nodules from Kware Mudstones. Note the radial crystal growth and concentric oxidization bands on the broken specimens.

The stratigraphic nomenclature follows exactly that of Mr. Rickwood, as the geological formations are more or less continue over the whole island. The oldest rocks exposed are the lavas of the Alite Volcanics ; above these we find the mudstones, limestones and calcareous sediments of the Malaita Group.

* C. G. & M. R., Vol. 6, No. 3, 1957, Geological Reconnaissance of Parts of the Central Islands of the B.S.I.P. by the Dept. of Geology and Geophysics, University of Sydney.

The limestone overlying the mudstones is of the order of 2,000 ft. thickness. This is somewhat less than the complete succession of the Malaita Group described by Mr. Rickwood in the north, and may be due to deeper water origin. Within members of this sequence are localised facies changes : cherty, silt-like, massive, and reef facies ; but none appears to be continuous over the area as a whole. Generally the limestone is massive, white, hard, and well-bedded, with a sub-conchoidal

fracture. The lack of any definite marker horizons makes the elucidation of the structure somewhat difficult, but I believe that the rocks are far more folded than I have shown in the map, and that overfolds might be shown if more detailed field work were carried out.

Relatively large areas of coastal flats have been noticeably extended around the southern coast during living memory. The southern tips of Small Malaita (Capes Hartig and Zelee) appear to be of recently raised coral limestone.

Recent movements have produced a general tilting of the island along its central axis. The drowned eastern shoreline has characteristic elongated harbours and inlets which are geographically controlled by the strike of the NW-SE folding. Emergence in the west has given rise to a well-developed platform with a line of elongated barrier reef islets parallel to the shore.

Malaita seems geologically and structurally a single unit. Its somewhat zig-zag form is because of the series of parallel fold structures that run *en echelon* in a roughly NW-SE direction. The steeper scarp slopes face north-east. Although both Rickwood and I have found ultra-basic boulders in the Kwaibeta River in the Kwara'ae District of Central Malaita, no major responsible shears which might be associated with them have been recognised—as in Choiseul and Santa Ysabel. Mr. Rickwood has suggested in a personal communication that he believes that the major folds may develop into shears at depth, and detailed mapping of parts of Kwara'ae and Koio Districts would elucidate this point.

In the northern part of Ari Ari the Alite anticline appears to divide up into three definite fold structures, Manawai, Harisi and Haukoko anticlines, which extend on into Small Malaita. Two folds parallel to the coast in

southern Ari Ari give rise to the finger-like peninsular of South Malaita—and extend across the passage into Small Malaita where they fade out as minor folds on the western limb of the dominant Alite Anticline.

No major folds have been recognised in the large Wairaha River Basin, and the more or less simple denudritic pattern suggests that the area is one of a simple dip slope on the western flank of the Alite Anticline.

Few dips have been taken on the lava outcrops of the Alite Volcanics, but they appear to conform roughly to the more obvious fold structures in the sediments above. This suggests that there has been only one period of folding. Incompetency of the Kware mudstones has been responsible for differential movement between the plastic limestones above and the more solid volcanics beneath. This has resulted in intra-formational folding of the Kware Mudstones and the lower beds of the limestone group.

Stratigraphy

	N. Malaita	S. Malaita
	Coralline Limestone.	Coralline Limestone.
Malaita Group	TOMBA Silts 800 ft.	
	SUABA Chalk. 2000–2500 ft.	
	ALITE Limestone. 2000–3000 ft.	ALITE Limestone. 2000–3000 ft.
	KWARE Mudstones. 400 ft.	KWARE Mudstones. 200 ft.
Alite Volcanics	FO'ONDO Clastics. FIU Lavas.	FIU Lavas.



PLATE IV

View from the top of limestone escarpment at Harisi Village, looking south across South Malaita towards Guadalcanal in the background. In the middle distance are the limestone hills of the southern limb of the Alite Anticline.

Alite Volcanics

This formation is fairly consistent over the whole of South Malaita, and cannot be subdivided. Being similar to the Fiu Lavas of North Malaita, the same name is being retained.

The Fiu Lavas often show excellent pillow structures; particularly in the Loaniura and Hurahura Rivers and in the headwaters of the Haupora River. Normal basalt flows are found within the pillow lavas and the local "basement" of massive flow rocks is of similar composition to the pillow lavas. These are exposed in the Wairokai, Haupora and Unua Rivers.

The Fiu Lavas vary from fine-grained basalts to a coarse dolerite (as in Maroupaina Bay). The fine-grained basalts (Spec. 3315) show very fine acicular laths of andesine/labradorite feldspar set in a matrix of sub-

pillow interstices, and forming a thin $\frac{1}{8}$ – $\frac{1}{4}$ in. coating to the lava surface. The base of the underlying Kware Mudstones appears to be conformable near Wairokai; elsewhere they are usually so distorted by intraformational movement that the true relationship is not apparent.

Kware Mudstones

The Kware mudstones are generally very well bedded and green in colour, although more yellowish facies are found. The lowest few feet are characterised by bands of green chert similar to the perlite glass of the lavas below. The mudstones usually show fine acicular crystals of palagonite together with occasional fine grains of pyrite. There is no calcitic cement.

Individual beds are generally thin, seldom exceed a



PLATE IVA

General view of a village at the south of Small Malaita, situated on coral detritus flats with fringing reef exposed at low tide. The river entering the sea at the right has inhibited the reef growth giving rise to this small harbour.

rounded augites. The interstices are frequently filled with chlorite and other decomposition products, with accessory pyrite. Some of the medium-grained basalts show feldspar and augite crystals in a green-brown glass (Spec. 3325), while the coarse dolerites have large labradorites interpenetrating large, cracked, and idiomorphic crystals of pyroxene, with but few accessory ore minerals. From comparison with Mr. Rickwood's report it appears that the volcanics of South Malaita seem rather less pyritic than those in the north, and this is probably reflected in the comparatively low number of pyritic nodules that are found here in the overlying mudstones.

The upper flows of the Fiu Lavas are well pillowed, with a characteristic green perlite glass filling in the

foot in thickness and contain an irregular and sparse distribution of pyrite nodules. Although these nodules are characteristic in the north, they appear to have only limited distribution in the south, and the only area where they have been found in relative abundance is in the Unua River and its tributaries. The nodules consist of radiating crystals of pyrite in round or sub-round concretionary form up to three inches in diameter. On weathering they become friable; when broken, oxidation occurs in marked concentric bands. (At one time the nodules were highly prized as club heads by the Malaita people and were thought to have "custom value". In more recent years they have been thought to be gold, and of considerable value. This idea is now rapidly losing favour.)

The actual thickness of the Kware mudstones is difficult to determine, but is much less than in North Malaita; it seldom exceeds 200 ft. (as in the Unua headwater exposures). In some outcrops, as in west bank tributaries of the Roapou River, the mudstones have a thickness of only 20–50 ft. They are thinner and indeed appear to be absent in some places (as in the Siua, and Tapairou, headwater areas). Though so distinctive that the mudstone would be difficult to overlook, these areas are all folded, and this originally incompetent band may well have been squeezed out altogether.

Alite Limestones

This thick massive formation which crops out over half of Southern Malaita has not yet been sub-divided. Variations of its composition appear to be largely due to local facies changes, but without slow and detailed field work it would be difficult to confirm this by tracing the beds over any great distance—they are often tightly folded.

The limestones are usually well bedded with individual bands varying in thickness up to 2 ft. There are massive strata of an off-white colour and others closely resembling modern reef limestones which weather to irregular cavity-riddled blocks.

The base of the limestones is characterised by thick beds of red/brown radiolarian chert in which “ghosts” of larger foraminifera can occasionally be seen. These chert bands are well exposed in Takataka Bay, where the shore beach deposits consist of small angular cherty fragments one to two inches in diameter.

Higher up in the succession the cherts are again to be found, but their distribution is irregular and in concretionary lumps—probably comparable to the flints in the Cretaceous chalk of England. They have quite irregular shapes with little or no relation to the bedding of the parent limestone. In the Waitahu River and near Harisi village many round cherts were found, but do not appear to be fossil replacements, as is so often the case with the English flints.

So far no detailed work has been carried out on the foraminifera of the South Malaita Alite Limestones, but *Globigerina* sp. are dominant. *Lepidocyclina* sp. and *Orbulina* sp. are also believed to be present. An elongated conical foraminifera has also been noticed in several sections. Individual specimens of limestone vary greatly in their foraminiferal content. The better-bedded variety seem richest in individuals but poorest in genera. No large foraminifera or mollusca have been found.

Several limestone specimens have been crushed and dissolved in hydrochloric acid, but no identifiable mineral fragments have been recognised.

The absence of silty horizons, mineral grains and molluscs suggests that the limestones of South Malaita were of deeper sea origin than those in the north. In Small Malaita some of the beds exposed are believed to be stratigraphically higher than those found elsewhere and may well provide geological historical data concerning the folding which has not yet been dated. We believe it to be of late Pliocene age.

In more recent time reef development has continued, and pulsating uplift of Small Malaita at Cape Hartig and Cape Zelee has given rise to a limited area of stepped terraces. The whole island of Malaita gives the impression of undergoing tilting about a central NW-SE axis with quite extensive fringing reefs, and a parallel line of off-shore barrier type coral islands. A noticeable uplift of about 3 ft. was reported at Rohinare at the time of the 1930 earthquake; before this it was possible to travel by canoe from Ohu to Kiu for almost 30 miles, without entering the open sea*, but this passage is now closed beyond Rohinare, where the earthquake effects seem to have been most noticeable.

Pyritization is noticeably less than in the northern end of the island. The pyrite of the Kware mudstones is only of academic interest.

II. The Island of Small Malaita

The Kware mudstones which were prominent on Malaita itself have not been found, substantiating Mr. Rickwood's expectation that these beds would become thinner and fade out in the south. They had almost faded out at Takataka. Repeated questionings of the people suggest that the distinctive pyrite nodules, usually associated with the Kware Mudstones, have not been found anywhere on Small Malaita.

The volcanic rocks of Small Malaita are mainly amygdaloidal basalts markedly different from the pillow basalts found on Big Malaita in the Takataka/Wairokai area of Ari Ari, which had been mapped previously. Boulders in the streams are more spheroidally rounded than usual, and at first sight suggested derivation from an old beach deposit. Vesicles are frequently large, 1–2 mm. in diameter, giving the rock type a characteristic appearance. Pillow and flow lavas have been seen in the centre of the island near Hoti, but for the most part glassy amygdaloidal basalts seem to be the rule. Limestones with inclusion of fragments of these lavas were seen in several places along the Walande-Riverside track. These outcrops were not the base of the Malaita Group, and field evidence suggests that limited limestone deposition must have occurred during lapses in volcanic activity. The glassy lavas were most probably ejected as bombs; this would account for their rounded agglomeratic appearance and loose cementation by calcium carbonate. Good exposures were seen around Mobo Harbour, but other inlier outcrops in the Supaina and Sumoimoi Rivers have been inferred from stream boulders in conjunction with photographic interpretation.

Fine radiating crystals of plagioclase feldspar are set in a brown semi-opaque glass with small crystals of augite and zeolite-filled vesicles. The rims of the vesicles have a narrow margin of a yellowish decomposition product or alteration mineral.

The sediments of the Malaita Group are normally well bedded and often show a type of varving, apparently due to muddy impurity at the base of each individual bed; the beds vary from $\frac{1}{2}$ in. to 2 ft. in thickness, but

* According to Rev. Fr. Van de Walle at Rohinare Mission.

3 in. to 6 in. is most common. In the north near Heranisi and Mobo, where the tracks pass over the geological succession, massive limestones form the base of the group. The calcareous sediments differ in character from those previously mapped on the mainland; here on Small Malaita they are almost entirely of calcareous siltstones and mudstones instead of massive limestones as on Big Malaita. This is probably due to deeper water deposition. It has been suggested that the sediments on Small Malaita are younger than those on the mainland, and foraminifera determinations on the specimens collected on this recent visit should clarify this point.

The structural pattern of Small Malaita is contiguous with that on the mainland—a series of parallel folds running NW-SE. Along the north-eastern coastline the folding is intense and steep, but to the south-west on the southern flanks of the Alite Anticline the folding is more gentle. Intraformational folding has been seen in the Tarapaina Bay area on a small scale, well-exposed in the creek to the east of Tauri village; slight clinorial buckling is evident on the flanks of the main structural folds. Apolato Hill, between Walande and Hoti, is a prominent feature representing a tightly folded anticline; it shows up well on the aerial photographs. In the Tarapaina area there has been faulting associated with the folding, and this probably accounts for Oranu Island being volcanic, while all the neighbouring islands are of sedimentary origin.

The topography of Small Malaita is closely related to the geological structure. Apart from the main outcrop area around Ro'one the volcanics are exposed in river

valleys eroded along the axes of the anticlines. The topographic expressions of the different rock types is not so marked as on Big Malaita. Intense folding and recent weathering effects have obscured the picture as seen in aerial photographs. Karst topography is well developed along the southern coast on the more gently sloping flank of the Alite Anticline, and large potholes up to 40 ft. deep were seen during the traverses across the island.

Probably the most striking feature of Small Malaita is the Maramasike Passage, which separates the island from the mainland. Entirely an erosional feature, the passage is most probably a drowned river (as Mr. Rickwood has already suggested). Its somewhat zig-zag form is closely related to the geological fold structures which cross it at right angles. The northern end of the Passage is very shallow and the bays around Tarapaina are only a foot or so deep with a soft muddy bottom in which cockles flourish.

III. Economic

Garnet and ilmenite gravels are found in streams on the east side of Malaita, and these have been dealt with in Report No. 15. No economic minerals have been found in Small Malaita.

In the past the villages along the northern coast of South Malaita have utilised "coral cement" from local materials, and built several large churches, which have stood up well for 20-odd years. I saw no cement being made today, nor any example of its use in recent years, but the practice should be revived, as imported cements are so expensive in the Solomons.

REPORT No. 6
LAVAS FROM SAVO VOLCANO

By J. KERRY LOVERING

(Bureau of Mineral Resources, Geology and Geophysics, Canberra, Australian Capital Territory)

Olivine-pyroxene andesite (slide 2791) was collected* from deeper flows exposed in the gorge through the old crater wall. The rock consists of numerous zoned diopsidic augite (20%) and plagioclase (45%) and irregularly-shaped magnetite grains (36%) in a matrix of microphenocrysts of plagioclase, augite, magnetite and interstitial chlorite and accessory minerals. The zoned plagioclase phenocrysts are arranged in a sub-parallel fashion indicating flow movement. The plagioclase phenocrysts consist of bytownite cores surrounded by labradorite zones. Some labradorite zones in every grain have numerous dark inclusions, some of which appear to be glass and some iron ore.

phenocrysts and some biotite and green hornblende phenocrysts are set in a very finely vesicular matrix of microcrystalline feldspar, particles of iron ore and accessory apatite needles. Phenocrysts of plagioclase are about 1 mm. in size.

The plagioclase consists of labradorite cores surrounded by andesine; some of the cores may be xenocrystic in origin, as the core margins are so irregular.

The rock is a *biotite-hornblende andesite*; the percentage (5 to 7) of ferromagnesian minerals is unusually low for an andesite.

The pyroxene andesite (slide 2793) is compact; it contains numerous black phenocrysts.

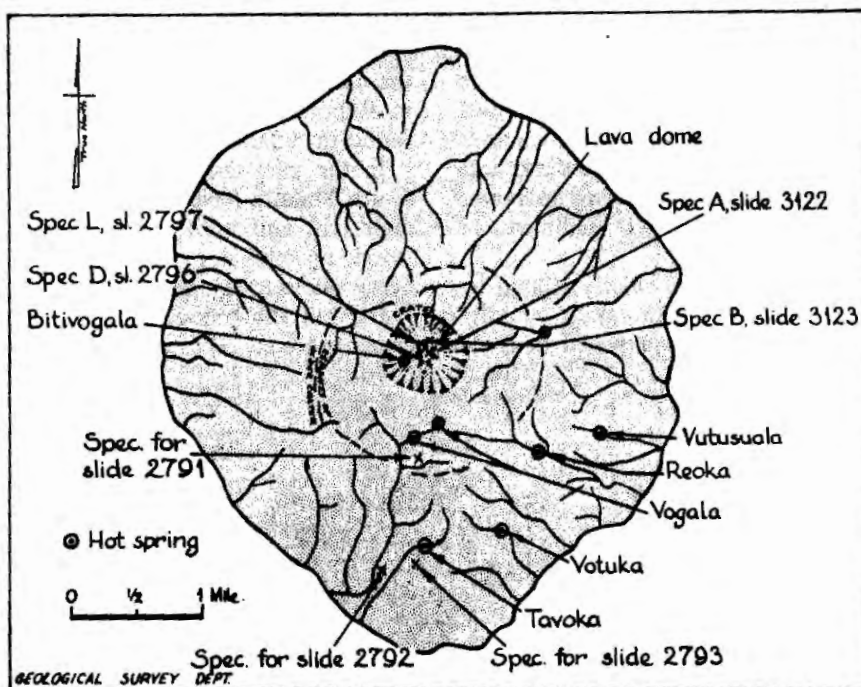


FIG. 8.—Map of Savo showing specimen locations.

Euhedral olivine grains (3%) are accessory and are replaced, for the most part, by fine-grained serpentine, carbonate and hydrated iron ore.

Apatite needles are also accessory.

The overall darkness of the rock can be attributed to the dark inclusions in the plagioclase grains, to interstitial chlorite in the groundmass and to the large pyroxene phenocrysts. The rock is an olivine-pyroxene andesite; or a basaltic andesite; to determine the correct name, a silica analysis would have to be made.

The biotite-hornblende andesite (slide 2792) from the last *nuee* eruption was collected from a creek leading down from the crater. It is typical of lavas in the fragmental rocks.

The thin section reveals that abundant zoned feldspar

Phenocrysts about 1 mm. in size, of labradorite surrounding bytownite cores, clinopyroxene and pseudomorphs of amphibole (lamprobolite) lie in a matrix of microphenocrysts of feldspar and pyroxene, and subhedral and anhedral grains of black iron ore. The amphibole pseudomorphs consist of magnetite, pyroxene, and plagioclase; only very little lamprobolite remains, and even this is somewhat bleached by incipient alterations.

Apatite is an accessory mineral.

The rock is a *pyroxene andesite*; lamprobolite was originally abundant, but is now represented almost entirely by pseudomorphs.

All the specimens from the lava dome have approximately the same textures and approximately the same percentages of phenocrysts.

* By Dr. N. H. Fisher and J. C. Grover, in 1956.

The biotite-lamprobolite andesite (slide 2796, Savo D) collected by Mr. Grover appears to be a medium-grained tuff in hand-specimen.

In the thin section are euhedral and subhedral grains about 1 mm. in size, of feldspar (45%), red lamprobolite (7%), brown biotite (5%) and magnetite (5%) in a cryptocrystalline groundmass.

The feldspar grains are strongly zoned; andesine cores are surrounded by zones of oligoclase. Some of the zoning is so sharp that the cores may be xenocrystic in origin.

The hornblende andesite (slide 2797, Savo L) is a pinkish-grey, slightly weathered specimen collected by Mr. Grover from the dome: it is similar to Savo D with the exception that its amphibole is brown hornblende.

The biotite-lamprobolite andesite (slide 3122, Savo A) is a light grey rock in which are white phenocrysts in a fine-grained groundmass. A large black xenolith about 2 in. in diameter occurs in the rock.

The rock contains euhedral feldspar grains (50%) about 2 mm. in size; oligoclase is zoned about an andesine core. Smaller grains of brown lamprobolite (7%) and brown biotite (5%) and magnetite (5%) and minute crystals and centres of incipient crystallization and clay particles are surrounded by a colourless glass with low refractive index.

Crystallization of the lava must almost have reached its present state when the black xenolith was engulfed, for the line of demarcation is distinct.

The black xenolith consists of two distinct layers. The fine-grained layer consists of grains about 0.5 mm. in size, of brown lamprobolite (60%) and bytownite (30%)

and magnetite (10%). The grains are combined in a hornfelsic texture which has a slight indication of layering. This part of the rock is hornblendite.

The second layer consists of brown lamprobolite grains (73%) about 1 mm. in size, lumps of apatite (2%) and interstitial plagioclase (10%) stuffed with minute lamprobolite grains; in parts magnetite (15%) binds lamprobolite grains. This part of the xenolith is hornblendite. The xenolith may well be cognate.

The biotite-lamprobolite andesite (slide 3123, Savo B) from the north side of the dome is a fawnish colour. The rock contains numerous white phenocrysts. Several small xenoliths about $\frac{1}{2}$ in. in size are present.

Phenocrysts of zoned feldspar (50%) about 2 mm. in size and small grains of red lamprobolite (10%), brown biotite (5%), magnetite (5%), accessory apatite, and incipient crystals and clay particles are set in a colourless glass with a low R.I.

The plagioclase core is bytownite; this is surrounded by zones decreasing in anorthite molecule to the small outer rim of oligoclase An_{27} . Some sections of bytownite enclose fawn glass.

The xenoliths in the rock consist of pyroxene grains, some of which are partly replaced by lamprobolite, and some olivine grains. Lamprobolite surrounds the pyroxene and olivine to form the rim of the xenolith.

The variation in the amphibole in the lavas, from red lamprobolite to brown hornblende, probably represents a difference in physical conditions in different parts of the magma.

The dome lavas most closely approximate to the biotite-hornblende andesite (slide 2792) from the *nuee* deposits.

OLDER LAVAS

NUEE DEPOSITS

DOME LAVAS

RECENT LAVAS

Slide No.	2791	2792	2793	2796 (Savo D)	2797 (Savo L)	3122 (Savo A)	3123 (Savo B)
Name	Olivine-pyroxene andesite	Biotite hornblende andesite	Pyroxene andesite	Biotite lamprobolite andesite	Hornblende andesite	Biotite lamprobolite andesite	Biotite lamprobolite andesite
Phenocrysts	Feldspar	Bytownite cores, labradorite 45%	Bytownite cores, labradorite 25%	Andesine cores, oligoclase 45%	Andesine cores, oligoclase 45%	Andesine cores, oligoclase 60%	Bytownite oligoclase 50%
	Pyroxene	20%	10%	—	—	—	—
	Amphibole	—	Pseudomorphed lamprobolite 10%	Red lamprobolite 7%	Brown hornblende 5%	Brown lamprobolite 7%	Red lamprobolite 10%
	Biotite	—	—	Brown 5%	Brown 3%	Brown 5%	Brown 5%
	Magnetite	3%	10%	5%	3%	5%	5%
Matrix	Micro-phenocrysts	Vesicular Micro-crystalline	Micro-phenocrysts	Crypto-crystalline	Crypto	Crypto* clay	Crypto* clay
Accessories	Olivine (3%) Apatite	Apatite	Apatite	—	Apatite	Apatite	Apatite

REPORT No. 7

THE RUSSELL ISLANDS—A GEOLOGICAL RECONNAISSANCE, 1957

By P. A. PUDSEY-DAWSON

Introduction

The Russell Islands are a small compact group situated about 20 miles to the west of Guadalcanal, and were visited for a week early in March 1957.

The group consists of the two larger islands of Pavuvu and Banika surrounded by a number of small flat coral islets, many of which are little more than slightly raised and sparsely vegetated sand cays. Others are planted with coconuts. The islands in the south and west have been raised about 100 ft. above sea level and are densely covered with primary jungle growth. The Russell Islands as a whole have been upraised in recent times, and the coral reef deposits, which originally developed on the slopes of an older volcanic pile, now show wave-cut platforms at about 10, 30 and 100 ft. above sea level. These prominent geomorphological features are fairly consistent throughout the group.

All the plantations are situated on the raised coral reef deposits, and on Pavuvu and Banika the plantation boundaries consistently seemed to delineate the natural geological boundary with the underlying lavas. I asked the Agronomist with Levers Pacific Plantations Pty. Ltd. whether this was due to soil differences, but he said that the coincidence was merely due to the fact that when the plantations were first laid out, about 50 years ago, 100 ft. above sea level was believed to be the maximum elevation at which coconuts could be economically grown. As the general elevation of the recent coral deposits is about the same, it seems that the nuts might have been planted on these more or less flat areas for convenience, rather than because of any marked soil differences.

General Notes

There are only five native villages in the Russells, but the numerous coconut plantations owned by Levers Pacific Plantations Pty. Ltd. have a large labour force which is brought in from other islands. One plantation (Somata) employs only Tikopeans, and nearby there is the Tikopean resettlement village of Nukuferu, recently founded to alleviate over-population of the remote island of Tikopia.

During the Japanese War the American Forces had large bases in the Russell Islands, and the road and air-strips are still in moderately good condition. Overseas ships can moor alongside the war-time and post-war wharves.

A large part of the Solomon Islands copra crop is produced by the European-managed plantations of the Russell Islands.

Geology and Petrology

The islands of Pavuvu and Banika are of doleritic lavas and agglomerates, with elevated margins of recent

coral reef limestone, rising abruptly from behind a narrow shelf of recent coral and alluvial debris. In the west these cliffs have an especially marked appearance with a strong "nick point" at about 100 ft. above sea level, and also several other erosion features caused by periods of still-stand (Grover, 1955). Near Cape Marsh there is a plateau-like area with a flat top.

Ridges parallel to the shore, such as those on either side of Sunlight Channel and along the south coast of Pavuvu, were formed by off-shore reef development and subsequent uplift.

Dolerite crops out as the main core of Pavuvu and Banika Islands, which rise to 1,800 ft. and 760 ft. respectively. Of the two main lava types, the commonest is coarsely porphyritic; the other a finer-grained, darker grey rock with feldspar phenocrysts.

The augite porphyry dolerite is a purple-grey rock in the hand specimen, and large sub-rounded crystals of augite (up to 4 mm. in size) are prominent. In thin section these phenocrysts are seen to be set in a fine ground mass of acicular labradorite feldspar crystals together with a subsidiary amount of iron ores and smaller sub-rounded augites.

The fine-grained feldspar dolerite is dark grey in colour; phenocrysts are present but are small and inconspicuous in the hand specimen. In some specimens weathering has caused the feldspars to break down, leaving small vesicle-like cavities in the rock. In thin section the feldspar phenocrysts are seen to be well-developed labradorites, some showing zoning and minute inclusions. Augites make up about 15 per cent of the phenocryst mass though these are all partly altered to a brown decomposition product. The ground mass is of labradorite feldspars, augites and iron ores.

Above 500 ft. agglomerate outcrops seem to be the general rule, containing fragments of both lava types with a predominance of the coarse porphyritic augite dolerite. The darker fine-grained lavas have been seen as massive flows within the agglomerate on Pavuvu. On Banika they are spheroidally weathered.

Dips of the agglomerate were obtained at only two places and therefore have little significance. Outcrops are usually poor, even in the stream beds, as there is only a small flow of water except during rain; the water-courses are normally a tangle of dense jungle growth. Outcrops on the lower slopes are obscured by a mantle of soil and rock debris, but it seems likely that all the rocks here are of the coarse-grained porphyritic augite dolerite.

There are no ash beds or mudstones, nor any obvious crater. The general form of the islands is of long finger-like spurs running away to the north, which would indicate a centre of activity to the south. The Sunlight Channel may have major structural significance, but sufficient information is not yet available.



FIG. 9.—Geological sketch map of Russell Islands.

Soils of the Russell Islands

The nature and development of the soils in the Russell Islands is not yet fully understood. In the plantations on the two main islands there is an almost consistent 6-ft. cover of a red-brown lateritic clay over the limestone areas; on the smaller islands this mantle is less—about 2 ft. in thickness.

On the summit of Mane Island (100 ft. O.D.) several small fragments of volcanic material were found, up to 3 in. in diameter. There is no local lava outcrop, so I would suggest that either they resulted from explosive activity or were carried thither originally entangled in floating tree roots and other jungle debris. (On the Polynesian coral islands of Rennell and Bellona large rock fragments up to a foot in diameter are occasionally

washed ashore in driftwood.) Floating pumice also makes a notable contribution, as no doubt does airborne and seaborne ash.

There have been differences of opinion on the amount of lateritic residual material that can be weathered from coral limestone. It is important to note that there is no sign of local volcanic activity subsequent to the limestone deposition, and there are no definite zones of rocks or ash to be seen in the profiles of the limestone weathering products on which the plantations now stand, although volcanically derived erratics as described above are relatively common. Therefore volcanic enrichment of the one-time reef limestones must be due to floating debris or direct sedimentation—either mechanical or organic—from the sea water.

GIZO ISLAND—A GEOLOGICAL RECONNAISSANCE, 1957

By P. A. PUDSEY-DAWSON

Introduction

Gizo Island, in the New Georgia Group of the Western Solomons, is seven miles long and four miles broad, with the highest point about 500 ft. Though small, it has a sheltered deep-water anchorage suitable for overseas shipping, and is the administrative and trading centre of the Western Solomons.

There are only three native villages apart from the settlement of Gizo itself. The recently established village of Titiana on the south coast was established by the Government as part of a resettlement scheme for islanders from the overpopulated Gilberts, which are also part of the Western Pacific High Commission territories.

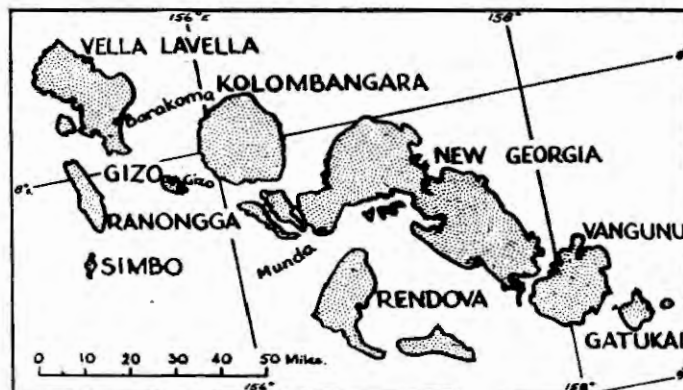


FIG. 10.—Sketch map of New Georgia Group.

Topography

Gizo Island is rugged; cliffs rise almost sheer from a low fringing coral shelf; the multitude of small coral islets and sand cays which are found to the north and east are evidence of uplift and constitute navigational hazards; the recognised passages suitable for the large ships, however, are well marked.

The north-eastern coastline is fringed with mangrove swamps, and the only method of travel is by canoe. On the southern coast a good track from Gizo follows the beach and raised coral bench as far as Sagiragi. The absence of this beach in the north, the presence of mangroves, and the drowned coastline, indicate recent tilting to the northward. Remains of tree trunks and uplifted



PLATE V

Typical house in the Gilbertese Resettlement Village of Titiana.

coral "nigger heads" further testify to minor changes of relative levels of land and sea.

The prominent Kongulavata Inlet in the north is due to a fault zone that almost bisects the island: both shores show a typical drowned valley form, with dense mangrove swamps between parallel faulted cliffs.

Geology

Clastic sediments overlies a pyroxene-rich basalt-andesite that is well-exposed in the east. The sediments have a north-north-east dip of about 15° , though faulting has caused localised variations. The dip corresponds well with geomorphological evidence of tilting, and is an original first order feature.

Agglomerates, mudstones and calcareous fragmental deposits at first sight appear to make three separate formations, but in point of fact may be only facies changes. Most of the island is agglomeratic, containing fragments of a wide range of rock types, and sections are particularly well-exposed in the cliff on the beach track (or trail) near Gizo Hospital. On the south coast an outcrop of fine tuffaceous mudstone appears to have been block-faulted up into the agglomerates; the actual time relationship is difficult to establish because of the lack of any definite marker horizon, but it seems as if the mudstones are older than the almost ubiquitous agglomerates. The summit of Maringe Hill is of a gritty and fragmental calcareous deposit with many large shells, small corals, lamellibranchs and foraminifera.

(a) Calcareous Deposits

Seen on Maringe Hill. This deposit probably occurs only at this one place. The ancient beach rock of calcareous sandy grit is rich in foraminifera. Study of

the faunal content by Dr. P. J. Coleman, Sydney University, shows the presence of:

Cycloclypeus spp.
Heterostegina sp.
Operculinella venosa.
Amphistegina lessonii d'Orbigny
Operculinoides sp.

and abundant Rotaliid spp.

which show the deposit likely to be of Pleistocene age.

(b) Agglomerates

These vary in both fragmental size and constitution, with blocks up to 2 ft. in diameter, loosely set in a yellow matrix, cemented with secondary calcite as found near the hospital at Gizo. Generally speaking, the beds are not well sorted, and fragments of all sizes are found together; but individual layers sometimes show good bedding over short distances. The finer material near Titiana seems to have poorly-developed bedding, and is unfossiliferous. There are some silt-like beds. Fragments of 2 in. to 4 in. in diameter are more common than the finer material.

Although classed as agglomerates, many of the beds have undergone water sorting and fragments have been rounded, probably representing shore facies.

The rock types in this clastic series cover a wide range from coarse-grained diorites to andesites and basalts. Until now little work has been done in the Western Solomons, which might suggest an obvious source. Similar rocks are also found on Ranongga. They probably represent the local "basement" as they resemble those found on Guadalcanal and Santa Ysabel. The recorded dip of the bedding suggests a volcanic centre to the south of Gizo, indicating possible faulting or down-warping on a large scale in the area between Gizo,

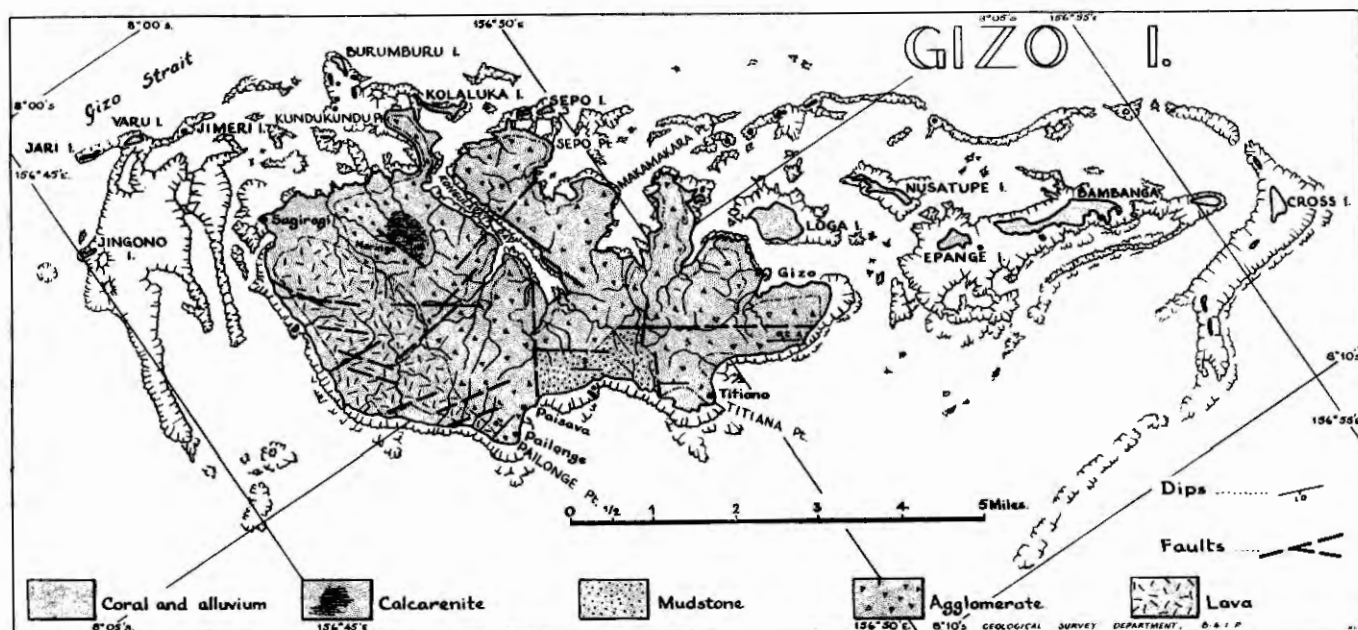


FIG. 11.—Geological sketch map of Gizo Island.

Ranongga and Simbo. Future study of these islands and Vella Lavella will give us a better understanding of past geological history and the regional structure.

(c) *Mudstones*

The mudstones exposed along the coast are commonly fine-grained and well-bedded with occasional conglomeratic bands. As a general rule the mudstones abut on to the coast and valleys as steep cliffs, due to the faulting; this can be seen both on the ground and from the aerial photographs.

The fine silt-like beds contain abundant foraminifera. The dips are generally less than those of the agglomerates, 5° to 10° being more common; faulting has probably altered their position of rest. In the absence of palaeontological data the mudstones must be considered older than the agglomerates.

(d) *Basalt-Andesite Lavas*

These lavas outcrop over four square miles at the western end of the island and are well exposed both along the shore and in the river beds. Weathering produces a knobbly and blocky outcrop with a strong north-south and east-west joint system. Some outcrops appear

pillowed. The area shows rounded topography and lavas that are almost black, fine-grained and with feldspar phenocrysts (2-3 mm.). In thin section the phenocrysts are seen to be of labradorite feldspar and augite set in a fine, almost glassy, matrix of acicular feldspars, sub-rounded augites, and iron ores.

Economic Possibilities

Although no indications of mineralisation have been seen on Gizo, the tuffs would provide an ideal building aggregate. At the present time gravel and sand are transported to Gizo from Honiara, but the local lightly-cemented tuffaceous agglomerates would provide all the materials required.

The beach near Gizo Hospital is of quartz sand, which is seldom found elsewhere in the Solomons and is far superior to the usual coral, feldspathic and mafic sands now used for building. These beach sands contain salt, which can be washed out. The agglomerate deposits are compacted and calcreted. Simple crushing and grading machinery could provide suitable building and road-making aggregate, thus saving the expense of importation by sea.

RANONGGA ISLAND—A GEOLOGICAL RECONNAISSANCE, 1957

By P. A. PUDSEY-DAWSON

Introduction

The volcanic island of Ranongga is a little over 20 miles long and 5 miles broad at the widest point. A field party was landed at Emu Harbour in the extreme north, and after having traversed the island and made three island crossings the party was picked up from Kongu, in the south. Unfortunately there are no aerial photographs of the island, and so we had no means of interpreting the geology without detailed river traverses. The map included in this report is thus more tentative than it might be: darker shading indicates the areas which have been examined.

Topography

Ranongga is elongated and rugged, with a central ridge higher than 1,000 ft. for much of its length, rising to about 2,000 ft. at Mount Kela in the centre.

The island shows a dip slope to the east with an almost sheer faulted cliff to the sea on the west coast. This has given rise to steep torrential streams in the west, and longer, less-steep ones to the east.

Both ends of the island are relatively low, with recently uplifted limestone cliffs and fringe of coral reefs. In the north are the two good harbours of Koreovuku and Emu. Pienuna is the only other sheltered anchorage—in the lee of Injaru Island—in the centre of the east coast.

The steep cliffs on the west coast at Mondo indicate a major fault feature. About a mile south of the village there is a hot spring in the sea a few yards offshore: best seen at low water, it was high tide at the time of our visit and we were unable to examine it. The water is said to be boiling.

Geology

The geological succession appears to be:—

4. Recent Coral Limestone
——— (Uplift)———
3. ? Pleistocene Limestone
2. Agglomerates and Mudstones
1. Lavas (Pliocene?).

The time relationships of the various clastic rock types are difficult to determine, and they may be only different facies, as on Gizo Island.

The lavas, which appear to be the oldest rocks exposed, have only been seen in the extreme south-west between Keara and Lale, where the massive basaltic flows along the beach are overlain by agglomerates.

The agglomerates in the western half of the island are typically unsorted; blocks vary in size up to 3 ft. across, set in a fine consolidated matrix of clastic material.

The sediments in the north and east are fine-grained, silty, and of marine origin—shown by the presence of

foraminifera. These sediments are probably, in part, outwash fans from the unsorted volcanic pile to the west. The coarser unsorted bands of tuff are particularly rich in well-formed crystals of augite, and were apparently laid down during the volcanic outbursts.

Intermittent vulcanicity was apparently succeeded by a period of quiescence during which time limestones were deposited on the eastern flanks of the island. These limestones have been found at a height of 750 ft. above sea level, and have a rich fauna of recent corals, gasteropods, lamellibranchs and foraminifera. The only actual outcrop visited on the hill was behind Rava village, but similar boulder specimens from the Ombombolu River indicate the presence of other outcrops in this area. Uplift in Recent times occurred after the deposition of the high level limestones, after which further recent limestone deposition recommenced along the length of the island.

A recent limestone platform has emerged 20 ft. along the length of the island in the north, and up to 140 ft. in the extreme south: where the high cliffs abut directly on to the open sea with a narrow shelf at their base about 10 ft. above sea level; this shelf is densely covered with small coconut groves.

No limestone was noted on the west coast during visits to Mondo and Keara.

Slight drowning of the coast in very recent times near Poroi is indicated by many tree trunks and palms standing in the water about 30 yards offshore. There has also been considerable erosion along the eastern coast, where many coconuts have been eroded away and felled onto the beach. The coastal storm beach is steep, of grey and black sands extremely rich in elongate and rounded augite crystals from the adjacent tuffaceous sediments.

(a) Lavas

The basaltic lavas outcrop intermittently along the beach between Keara and Lale. They are moderately resistant to weathering and form a relatively flat pavement along the shore overlain by agglomerates. They are usually pale in colour with phenocrysts of augite and labradorite feldspar set in a fine matrix of feldspars and pyroxenes. The rocks are vertically jointed at 150° and 70° (magnetic) with a subsidiary parting at 260° dipping south at 50°; this may represent an old bedding plane.

(b) Agglomerates

The agglomeratic fragments are all of basaltic lavas with phenocrysts of augite, hornblende and feldspars in a fine to glassy matrix occasionally showing alignment of the elongate and acicular crystals: on weathering the rocks become soft and tuff-like in character. A few large volcanic bombs 1 ft. in diameter have been found, consisting of an agglomeration of small crystals of horn-

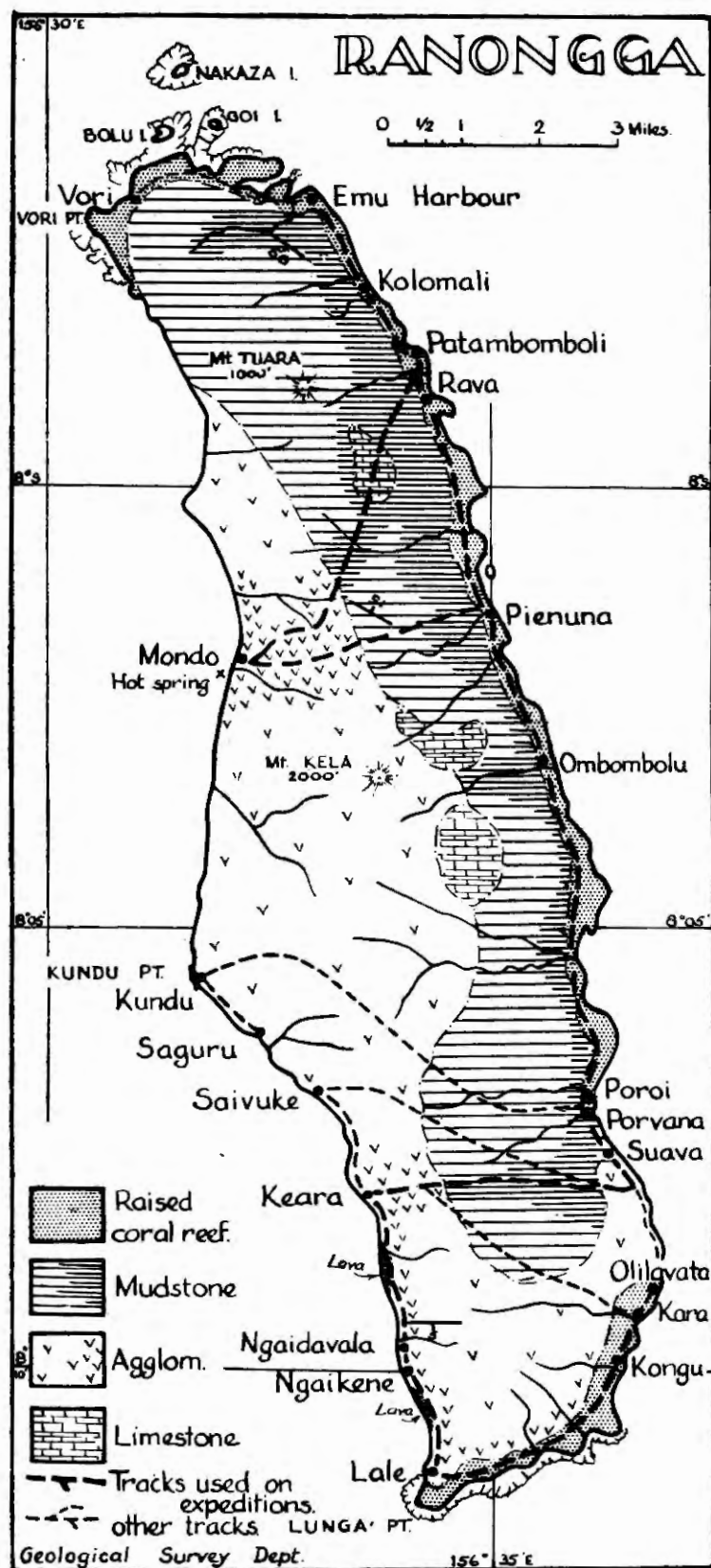


FIG. 12.—Geological sketch map of Ranongga.

blende. The tuffaceous matrix of the agglomerates is fine-grained and felspathic, with well-developed crystals of pyroxene and amphibole, from which have been derived the black sand beaches on the eastern coast.

(c) Limestones

The limestones are similar to the Miocene-Pliocene Limestones that are found elsewhere in the Solomons. In the north they are white and massive, often weathering to a very irregular and knobbly form. In the south between Lale and Konga they become less massive and may be classified as calcareous mudstones.

Conclusions

With only the eastern coastal areas having been surveyed in any detail it is difficult to evaluate the structure of the whole of the island of Ranongga, of which no

aerial photographs are available. Dips of the sediments are generally easterly on the eastern flanks of the agglomerate pile in the centre of the island. Mount Kole has not yet been visited, but from the fleeting visit to Mondo, when a good cross-section of the island was seen, it would seem that the major fault along the west coast has cut off the original volcanic centre ; and that Ranongga is comparable to Gizo Island : where we again find only easterly-dipping sediments.

A detailed study of the neighbouring islands of Simbo, Vella Lavella and Gizo will in time elucidate the geological structure of the area, but the area is one of considerable volcanic activity, and recent faulting has probably been responsible for the present island shapes. Several earthquake epicentres have been reported in this area by the U.S.G.S. in recent years*.

* See previous *Geol. Survey Memoirs*, Nos. 1 (1955) and 2 (1958).

RENNELL ISLAND—PROSPECTING FOR PHOSPHATES, 1957

By P. A. PUDSEY-DAWSON.

Introduction

Rennell was first briefly visited by the Geological Survey in May 1956. Surface indications then* suggested that phosphate might be found over limited specified areas. A second field party landed in May 1957 and extensively pitted these areas located inland and to the west of Lavanggu.

At the time of this second visit the seas were particularly heavy and the voyage in the 60-ft. M.V. *Bina* took 22 hours instead of the normal 14. It proved impossible to venture around to the southern unprotected side of the island to Lavanggu. The party was landed at the only calm area in the extreme north-west, at Mangga-utu, and had to walk overland for 25 miles, climbing the 360 ft. high cliffs and crossing the irregularly weathered sharp outcrops of the most inhospitable limestone country, carrying all equipment.

pits were excavated along the track for a distance of about 1½ miles in an area where these nodules were common. No phosphate was found.

The soil profiles were similar in every pit, the upper few inches being black and humic. The underlying bright red-brown coloured clay extended down to limestone bedrock. In almost every pit the limestone profile showed extreme irregularity with chimney-like solution hollows up to 6 ft. or more deep. Some chimneys were only a few inches wide.

At the old village site of Mahanga a pit was dug in former beach deposits which were off-white in colour like those which were richly phosphatic on Bellona. However, assays of these samples indicated no phosphatic enrichment. In three pits at Malanga the upper 3 ft. of clayey sand contained flat platey fragments of a phosphatic limestone deposit showing a banded structure in

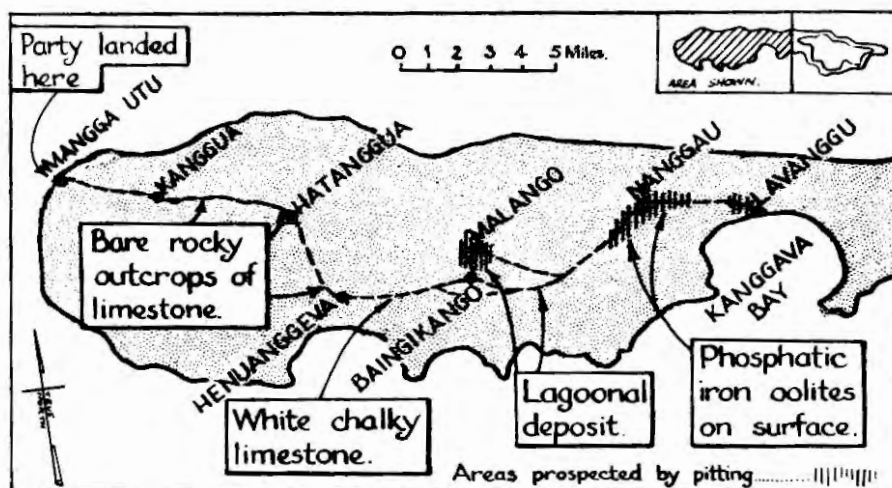


FIG. 13.—Sketch map of Western Rennell.

Prospecting Operations

During the walk, areas between the villages were noted to be mainly of bare limestone with primary jungle vegetation growing on the small intervening soil patches. The village sites and the neighbouring gardens were all in the large soil pocket areas. On the dark brown soil areas are small black oolites, locally called "kengehua", up to about ¼ in. in diameter: these are of phosphatic iron oxide (showing 2.8% on $\text{Ca}_3\text{P}_2\text{O}_8$ basis)†. Twenty

varying shades of brown. Individual pieces of this layer were less than 2 in. thick, so the quantity was negligible. It is similar to material found by Mr. Grover in the lake area at the eastern end of the island, and not unlike samples from the deposits at Ocean Island.

The limestone bedrock varied in appearance from a hard massive porcellaneous limestone to an almost chalky rock. Where the limestone was not massive, fossils had been leached out by solution leaving cast cavities.

Seventy samples were taken. A representative selection of these were tested for phosphate in our laboratory in Honiara; only two samples gave a positive reaction. These were sent to Mineral Resources Division in London for assay, and showed only 1.0 and 1.3% P_2O_5 . Both

* See *Memoir* No. 2, Chap. XXIV: "Rennell—the great uplifted atoll on the edge of the Coral Sea."

† Assayed by M. R. D. London, see *Memoir* No. 2 (1958), Chap. XXIV.

these samples were taken at the bottom of pits, directly above the bedrock, where one would expect a local phosphatic enrichment, if any.

The Rennellese have long recognised the low-grade phosphatic limestone layers which are locally called "malanga". The village with this name has an obvious derivation and the area is one of rich gardens showing that only a small amount of phosphate is necessary for

beneficial plant growth. Despite repeated questioning the local people could not show me another area where "malanga" was to be found, so it seems unlikely that there is any more.

Conclusions

No phosphate deposits have been found on Rennell in the part of it which has been explored.

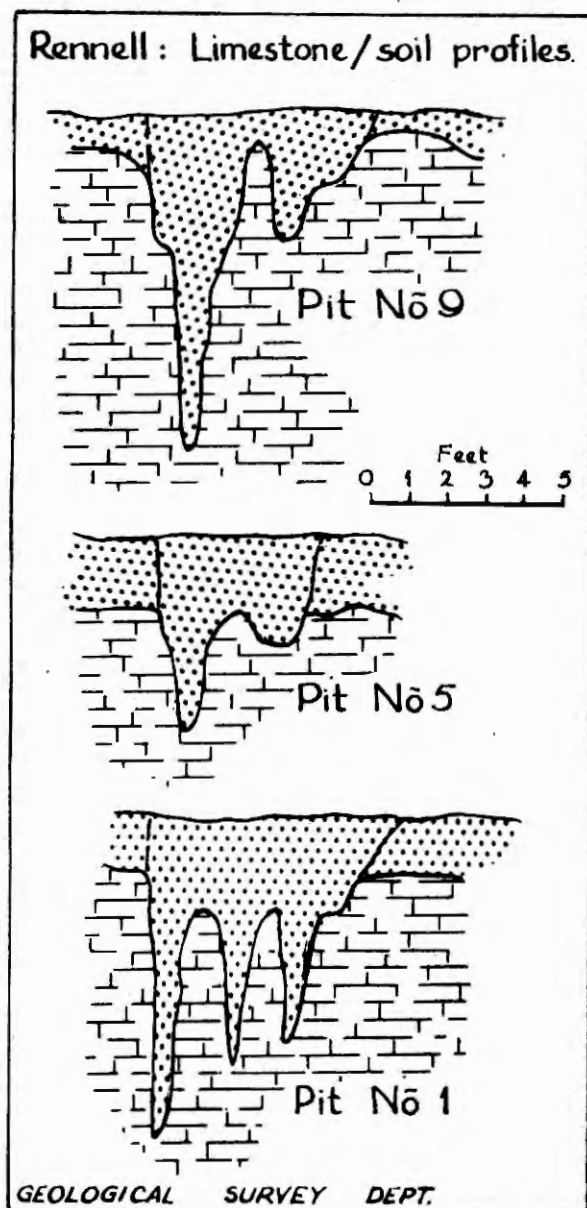


FIG. 14.—Sketches of Limestone and Soil Profiles as seen in prospecting pits on Rennell.

BELLONA ISLAND—FURTHER PROSPECTING FOR PHOSPHATES, 1957, AND A BRIEF DESCRIPTION OF GEOLOGICAL FEATURES

By J. H. HILL

Introduction

Bellona Island, about 100 miles south of Guadalcanal, is about six miles long and up to two miles broad. The island is elongated, with the main axis striking east-south-east. Coral cliffs rise from the coast to an encircling vegetated rim (about 260 ft. above sea level) from which the ground falls away to a fertile sunken valley extending along the main axis of the island: with gardens and coconut groves, bordered by secondary vegetation.

It was in 1956 that the economic implications of Bellona as a possible source of phosphate were realised, since when visits to the island have been more frequent and prolonged than hitherto. An expedition will visit the island in 1958 as part of a programme by the Australian and New Zealand Governments to appraise the phosphate resources of the south-west Pacific.

Heavy seas prevail for most of the year; May and October are recognised as the best months for visiting. Internal communications on the island are by means of a good path from Ahanga in the west to Peko in the east. Branching off from it are numerous narrow tortuous tracks to the various canoe shelters or fishing places on the rocky north and south coasts. The 12 villages are situated along the central track; with a population of about 500 Polynesians.

The only fresh water on Bellona (besides that collected in occasional rusty 44-gallon drums) lies in very small coral sink holes on the shore. Two are found immediately west of Tinggoa West; one is in a cavern, and the other a brackish spring which oozes through the sand between there and Kangibi.

Purpose of the Expedition

This was a "follow-up" of previous visits to the island by the Chief Geologist in 1956, when the higher-grade material at both ends of the island received most attention. The purpose of this visit was to gain more information concerning the great bulk of low-grade phosphates of iron and alumina along the centre of the valley.

Geology

Coral cliffs along the north coast stand directly from the sea except at Ahanga, Tinggoa West and Tinggoa, where there are beaches of coral rock and sand, 20 to 30 yards wide. Along the south coast a line of coral terraces and lagoons separate the seas from the base of the cliffs. A very slight northward tilt of 3° is indicated by clastic rock on the south coast; this is also observed

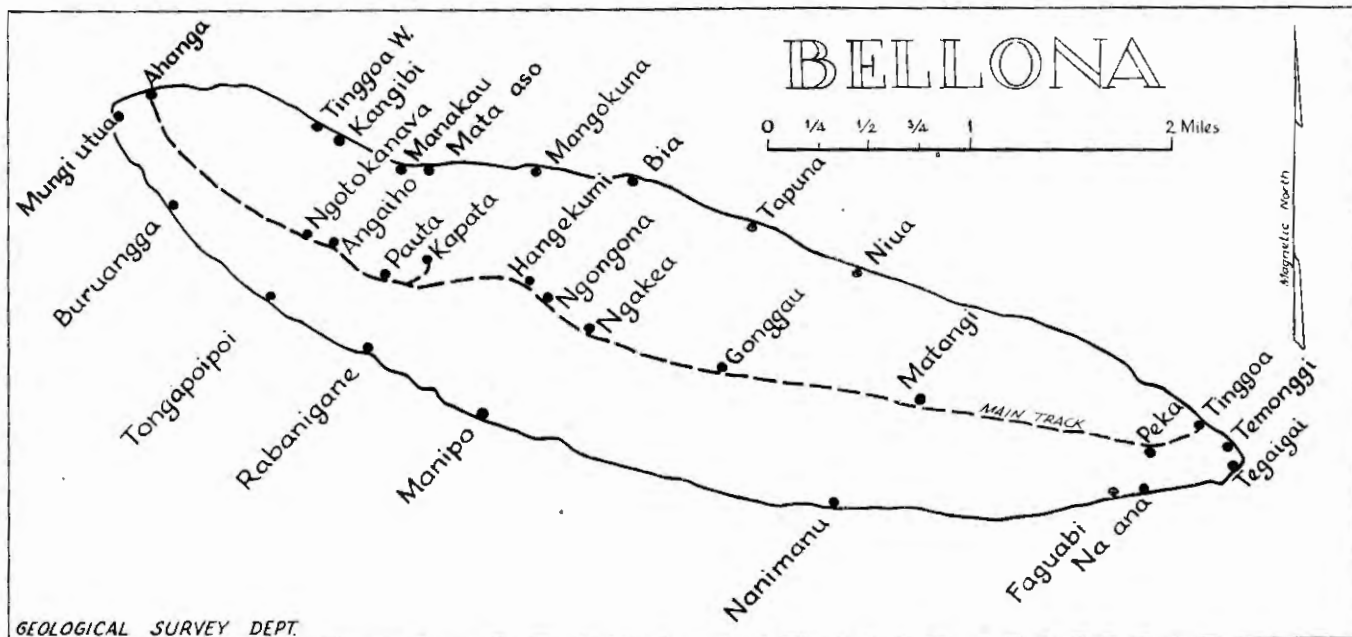


FIG. 15.—Sketch map of Bellona showing corrected village names.

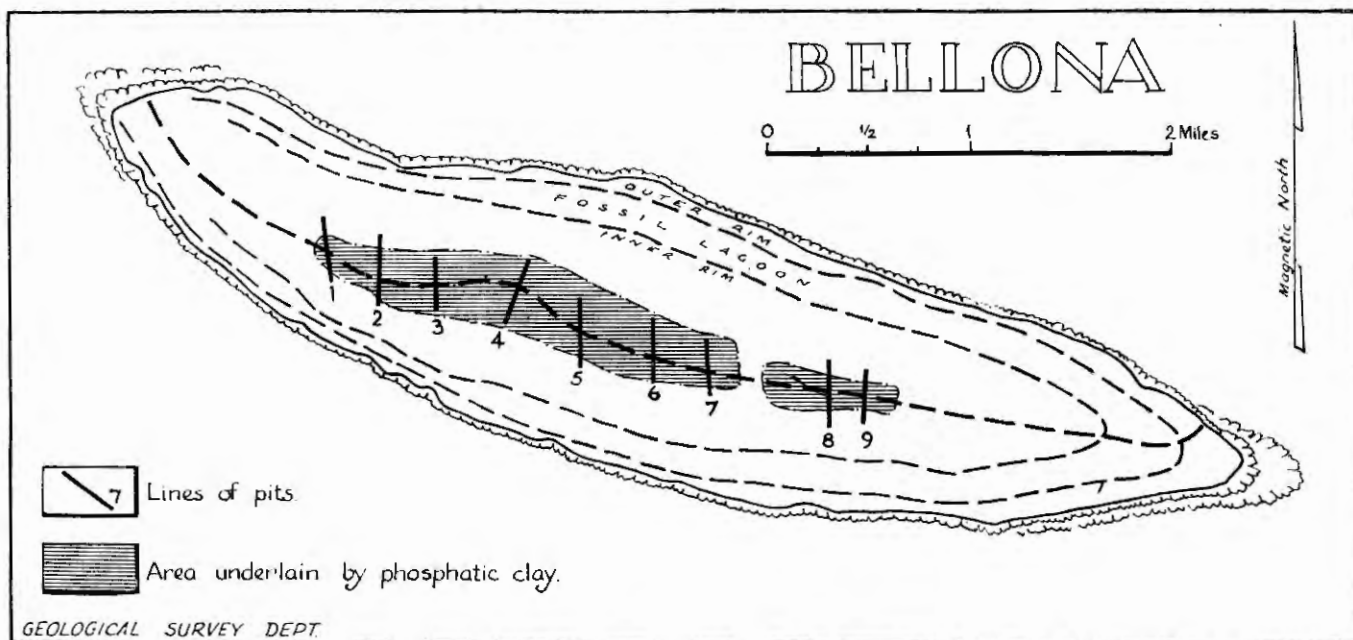


FIG. 16.—Sketch map of Bellona showing lines of pits.

in the 8-ft.-high coral terraces and lagoons which are better developed along the south coast.

During a number of north-south traverses the following features were observed :—

- (a) Less than 100 yards from the edge of the coral cliffs or fringing reefs the depth of water is great ; except at the east and west ends of the island, where deeper-water reefs are growing outwards for some distances from the shore.
- (b) Area of level fringing reef, 5 ft. to 40 ft. wide, broken by transverse erosion channels.

- (c) A shallow eroded tidal lagoon, 2 ft. to 5 ft. deep and 10 ft. to 100 ft. wide.
- (d) A platform at 8 ft.
- (e) A platform at 25 ft. to 30 ft.
- (f) A 100-ft. high platform or erosion cavern.
- (g) An outer rim.
- (h) Slight lagoonal depression.
- (i) An inner rim.
- (j) A sunken east-west central valley whose floor is close to sea level.

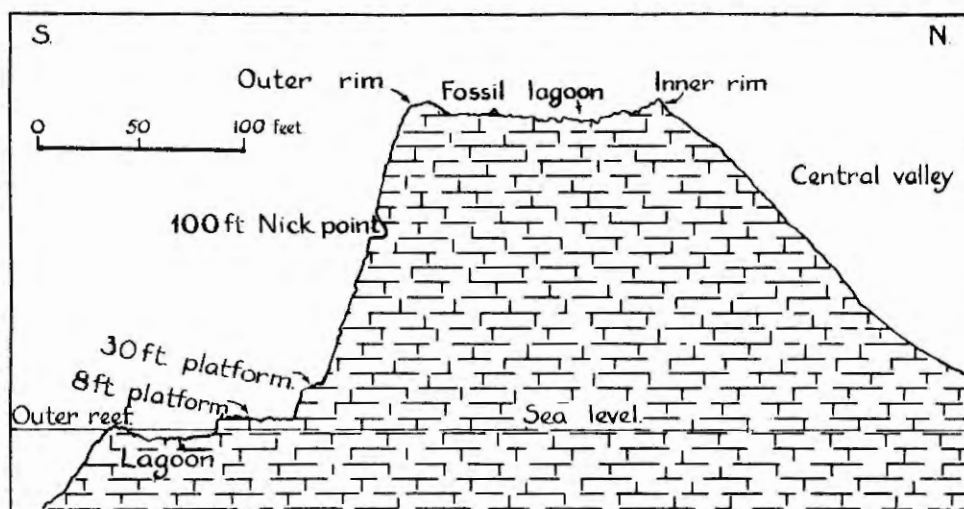


FIG. 17.—Sketch section of island rim and shoreline benches.

Phosphate Deposits in the Central Valley between Matangi and Ngotokanava

In addition to those excavated in 1956, lines of pits were excavated across the island in a northerly direction. Nine lines were excavated one-quarter to three-eighths of a mile apart, totalling 74 pits; 51 were dug through the "clay" to the bed rock of either hard or soft calcareous rock, or off-white material. Of the 23 pits not bottomed, 22 were not continued because of narrowing coral chimneys and funnels which made digging impossible. Except for the Kapata line all others were sited so as to avoid the scattered outcrops of coral exposed along the main east-west paths. Pits were usually excavated at 100-yd. intervals, but in the vicinity of gardens and villages this was not always practicable.

The majority of pits were in deeper material between the villages of Gonggau and Ngotokanava: where there was no rough coral terrain as in the east and west. The yellow-brown "clay" and off-white material were of less extent between Gonggau and Matangi.

Table I indicates where each line intersects the main east-west path and other relevant data.

(d) Soft, friable off-white phosphatic material.

(e) Hard or soft white calcareous deposit.

The different layers were sometimes absent or only poorly developed.

The coral underlying the central valley is a weathered formation of chimneys, projections and depressions blanketed by deposits of yellow-brown phosphatic "clay" with a considerable variation in thickness depending upon the profile of the underlying coral. The maximum relief of the coral (so far discovered) was found in pit 6/11 towards the southern end of the Gonggau line; the coral was reached at 26 ft.; 100 yards further southward, in pit 6/12, the coral is only 6 in. from the surface. Chimneys are frequently so narrow that pick and shovel excavation is impossible, and split-post augering was employed. A generalised picture of the coral bedrock can be envisaged with an irregular surface broken by deep tapering funnels and vertical chimneys, rather than pinnacles separating broad hollows. The contact between the yellow-brown "clay" and hard white coral is generally sharp.

TABLE I

Line	Intersects on main path Distance in yards	No. of pits	Width of "clay" zone	Average thickness of "clay"	Maximum depth of "clay"
1	20 W of Angaiho	6	330 yd.	8 ft.	19 ft.
2	30 E of Pauta	7	550 yd.	8 ft.	23 ft.
3	580 E of Pauta	10	580 yd.		14 ft.
4	Through Hangekumi	8	720 yd.	7 ft.	11 ft.
5	440 E of Ngongona	10	680 yd.	4½ ft.	16 ft.
6	720 W of Gonggau	11	570 yd.	8 ft.	27 ft.
7	160 W of Gonggau	6	440 yd.	7 ft.	16 ft.
8	820 E of Gonggau	7	280 yd.	4½ ft.	8 ft.
9	1,320 E of Gonggau	5	280 yd.	10 ft.	17 ft.

In sampling, a 6-in.-wide band was scraped clean from the surface to the base of each pit and ½-in.-thick samples were taken separately from the different zones of soil, sub-soil (transition zone), yellow-brown "clay", off-white material and bedrock coral.

The following is the sequence:

- Black to dark chocolate humic concolourous soil.
- Transition zone from black soil to yellow-brown "clay".
- Yellow-brown "clay" of phosphatic alumina and iron oxides.

The yellow-brown "clay" is a homogeneous deposit exhibiting little vertical or lateral variations throughout the whole length of the Bellona Valley between Matangi and Ngotokanava. It does not extend for more than 300 yards from the central path. Occasional weathered coral fragments and scattered silicified phosphate nodules up to 2 in. in diameter are found towards the base of the clay. In pit 9/3 from minus 8 ft., is a 5-ft. layer of "clay" containing numerous phosphatic nodules (up to 5 in. in diameter) and assaying 33.1% P_2O_5 .

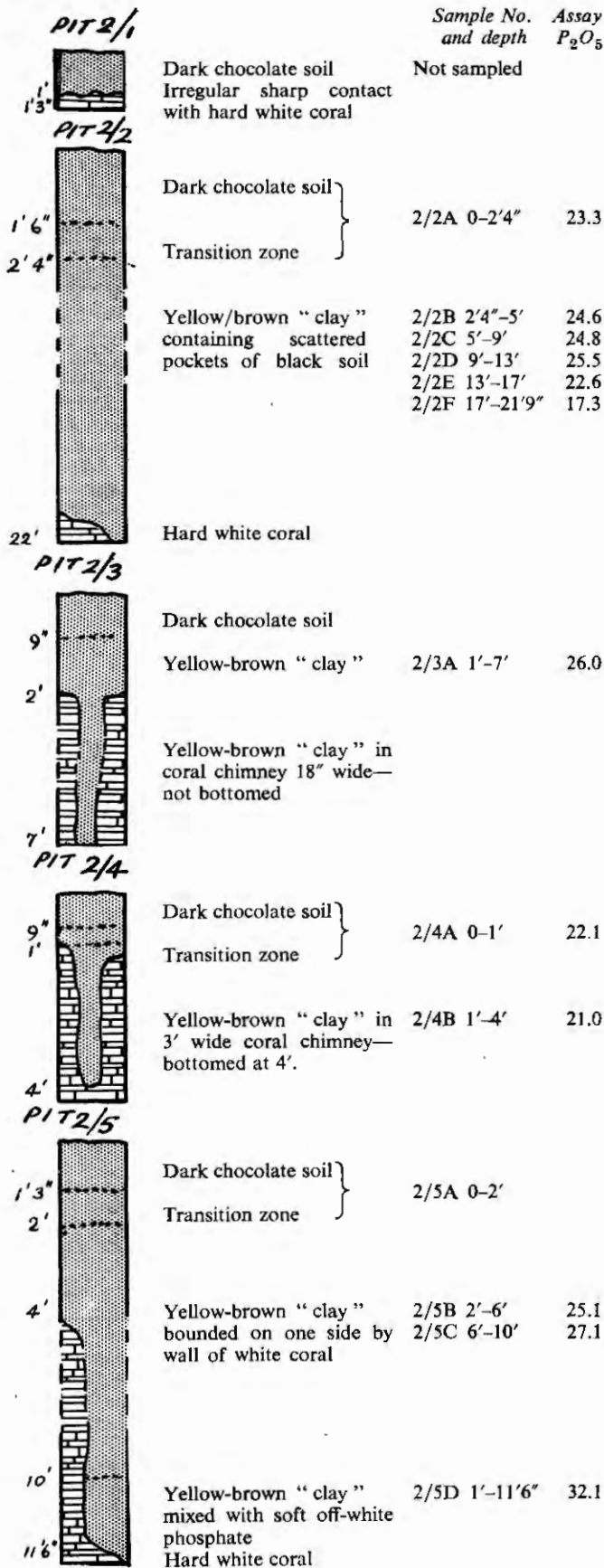
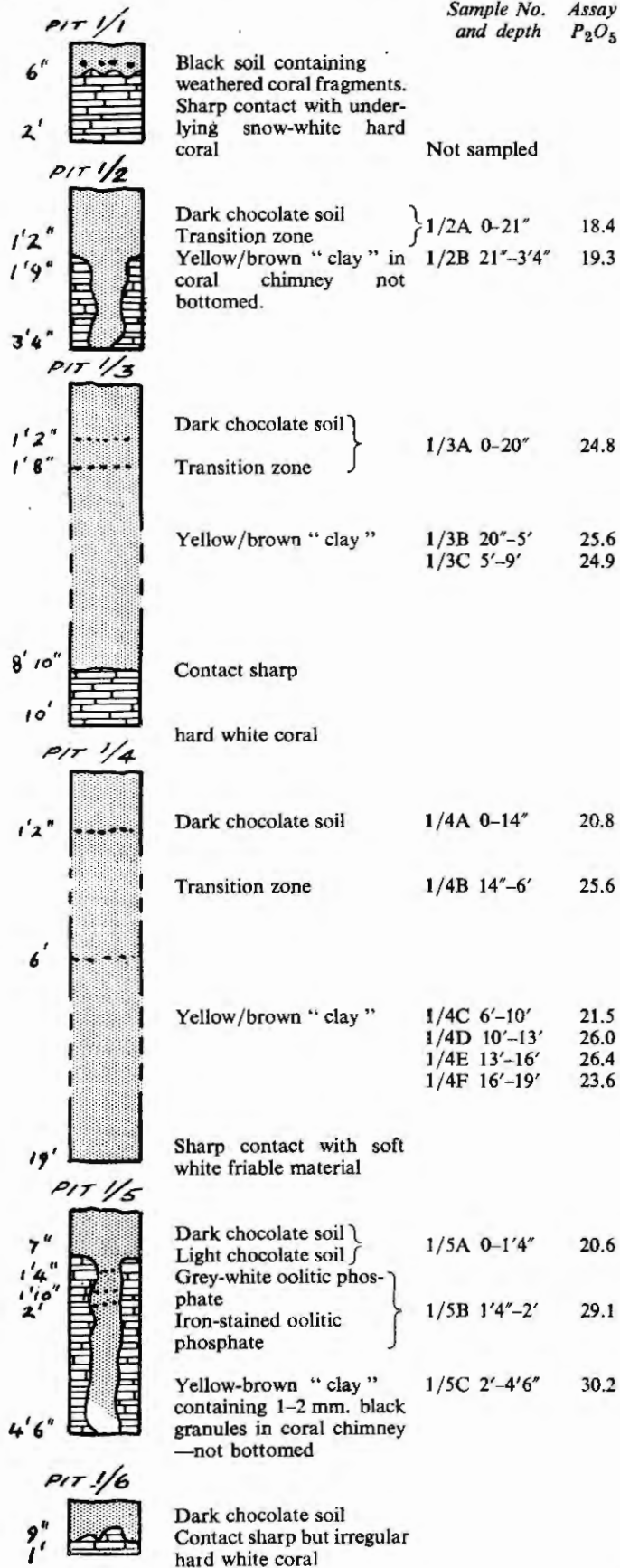
DETAILS OF PIT SECTIONS AND SAMPLING OCTOBER/NOVEMBER 1957

LINE No. 1

LINE No. 2

Sample No. and depth
Assay
 P_2O_5

Sample No. and depth
Assay
 P_2O_5



LINE No. 2 (continued)

		Sample No. and depth	Assay P_2O_5			Sample No. and depth	Assay P_2O_5
PIT 2/6		Not sampled		PIT 3/8			
1'	Dark chocolate soil			2'	Dark chocolate soil	3/8A 0-4'	22.8
2'6"	Yellow-brown "clay" in 18"-wide funnel				Coral fragments		
3'	White coral				Yellow-brown "clay" containing scattered 1/2" coral fragments. Chimney 2' wide—not bottomed	3/8B 4'-10' 3/8C 10'-13'	32.4 34.6
PIT 2/7		Not sampled		13'			
6"	Dark chocolate soil						
13'	Irregular sharp contact						
	White coral						

LINE No. 3

PIT 3/3		Not sampled		PIT 3/9			
1'	Dark chocolate soil			1'3"	Dark chocolate soil	3/9A 0-1'6"	26.2
	Hard white coral			1'6"	Transition zone		
PIT 3/4		3/4A 0-1'	8.5	12'	Yellow-brown "clay" in 4'-wide coral chimney—not bottomed	3/9B 1'6"-5'3" 3/9C 5'3"-8' 3/9D 8'-12'	22.6 23.0 26.8
1'	Dark chocolate soil with hard white coral just below surface						
	Yellow-brown "clay" in 18"-wide coral chimney—not bottomed	3/4B 1'-11'	23.3	PIT 3/10			
11'					Dark chocolate soil grading into yellow-brown "clay"	3/10A 0-2'	24.1
PIT 3/5				6'6"	Yellow-brown "clay" in 2'-wide coral chimney—not bottomed	3/10B 2'-3'9" 3/10C 3'9"-6'6"	15.8 27.0
6"	Dark chocolate soil						
	Yellow-brown "clay" in chimney 12" wide—not bottomed			PIT 3/11			
9'		3/5A 9'	21.6	9'	Dark chocolate soil	3/11A 0-1'3"	12.1
PIT 3/6					Transition zone		
1'	Dark chocolate soil	3/6A 0-1'	18.4		Yellow-brown "clay"	3/11B 1'3"-3'	13.4
	Yellow-brown "clay" in 12"-wide coral chimney—not bottomed	3/6B 1'-10'	19.4				
10'				12'6"	Yellow-brown "clay" in coral chimney—hole not bottomed	3/11C 3'-6' 3/11D 6'-9' 3/11E 9'-12'6"	23.6 22.1 23.6
PIT 3/7				PIT 3/12			
	Dark chocolate soil			1'6"	Dark chocolate soil	3/12A 0-1'6"	15.2
	Yellow-brown "clay" in 12"-wide coral chimney—not bottomed	3/7A 1'-10'	19.7				
10'				5'	Yellow-brown "clay" in 2'-wide coral chimney—not bottomed	3/12B 1'6"-3'6"	17.1

LINE No. 4

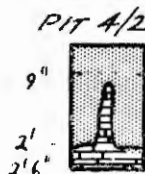
Sample No. and depth
Assay
P₂O₅



Dark chocolate soil

Yellow-brown "clay" in coral chimney

4/1A 8' Grab 21.7



Dark chocolate soil

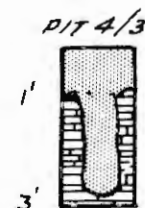
Yellow-brown "clay" containing pipes 6"-9" wide of soft coral

Soft white coral

4/2A 0-9" 20.6

4/2B 9"-2' 17.3

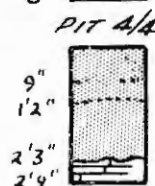
4/2C 2'-2'6" 1.7



Dark chocolate soil

Yellow-brown "clay" in coral chimney

4/3A 1'-3' 21.0



Dark chocolate soil

Transition zone

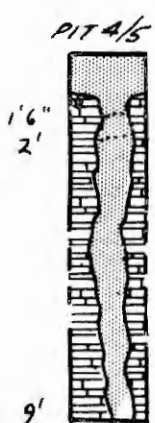
Yellow-brown "clay"

Contact sharp

Soft white coral

4/4A 0-1' 23.8

4/4B 1'-2'3" 23.6



Dark chocolate soil

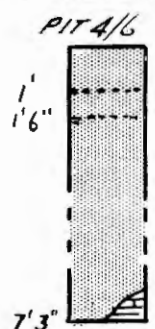
Transition zone

Yellow-brown "clay" containing scattered fragments of coral. Pit in 3'-wide coral chimney—not bottomed

4/5A 0-3' 25.8

4/5B 3'-6' 25.6

4/5C 6'-9' 26.5



Dark chocolate soil

Transition zone

Yellow-brown "clay"

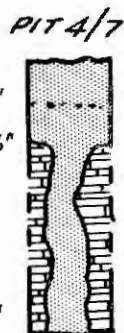
Contact sharp

Hard white coral

4/6A 0-1'6" 24.8

4/6B 1'6"-4' 27.3

4/6C 4'-7'3" 26.4



Dark chocolate soil

Yellow-brown "clay" in 3'-wide coral chimney—not bottomed

Sample No. and depth
Assay
P₂O₅

4/7A 0-1' 20.9

4/7B 1'-3'3" 22.3

4/7C 3'3"-7' 17.8



Dark soil containing fragments of coral

Hard white coral

Not sampled

LINE No. 5



Dark chocolate soil containing coral fragments

Hard white coral

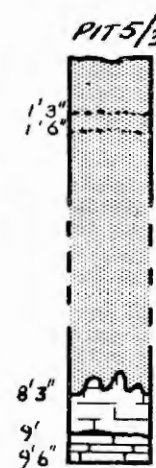
Not sampled



Black soil containing scattered weathered coral fragments

Hard snow-white coral

Not sampled



Dark chocolate soil

Transition zone

Yellow-brown "clay"

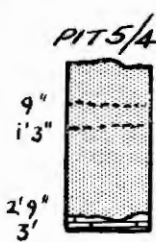
Contact undulating but abrupt. Soft off-white material underlain by hard white coral

5/3A 0-1'6" 22.8

5/3B 1'6"-4'6" 24.5

5/3C 4'6"-8'3" 25.0

5/3D 8'3"-9'6" 35.2



Dark chocolate soil

Transition zone

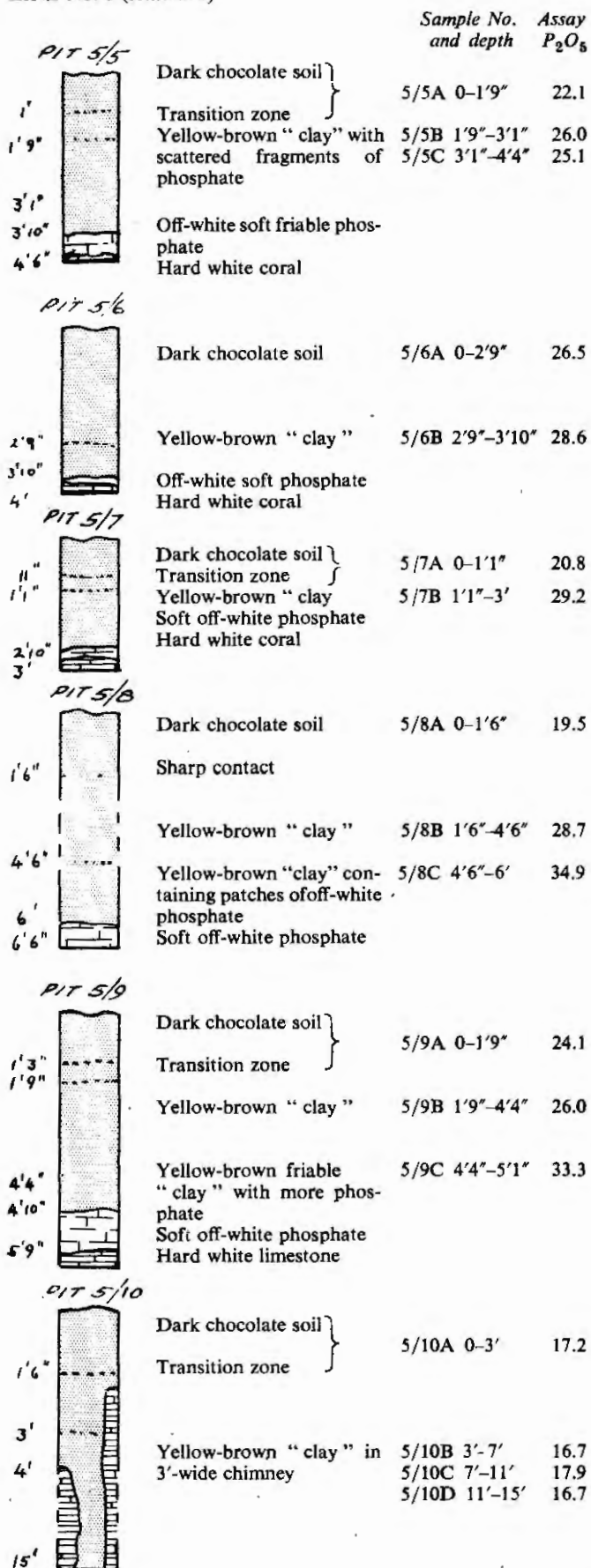
Yellow-brown "clay"

Sharp contact
Fractured and brecciated off-white coral

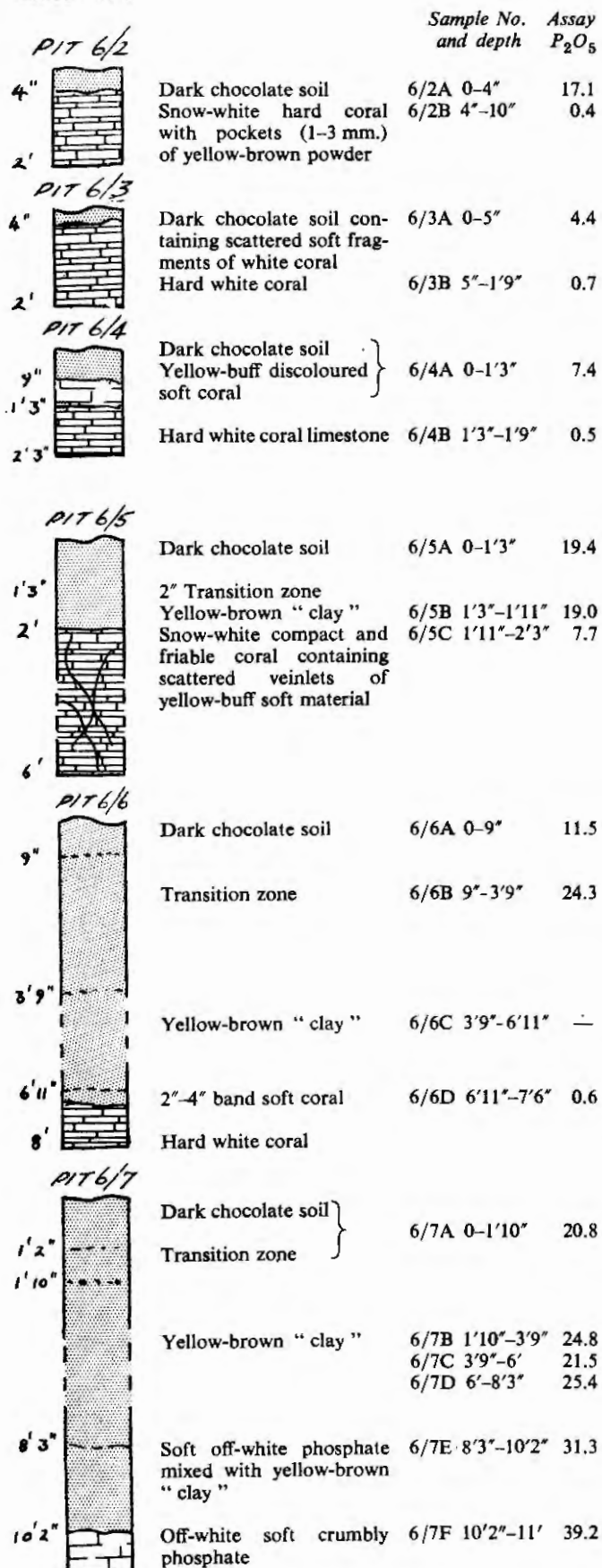
5/4A 0-1'3" 24.4

5/4B 1'3"-2'9" 26.4

LINE No. 5 (continued)



LINE No. 6

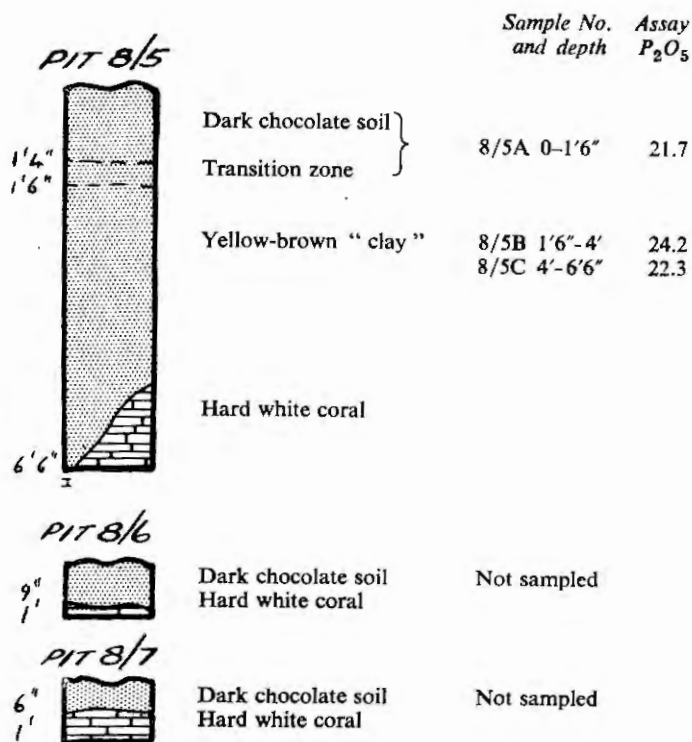
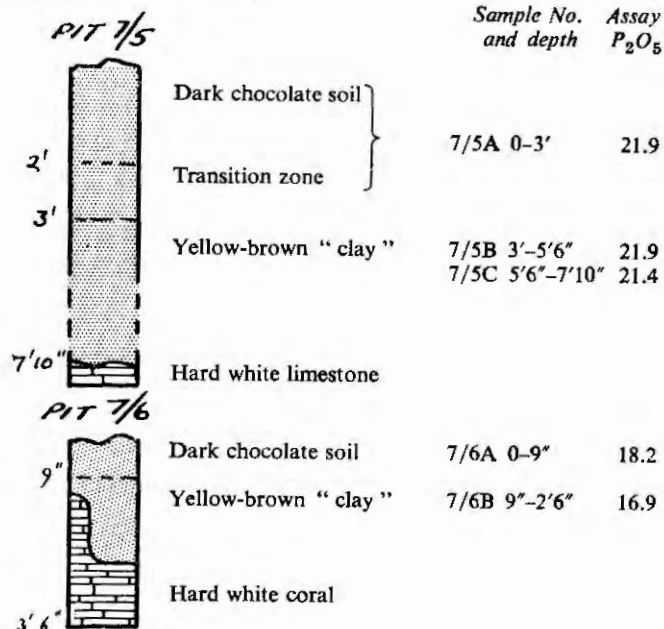


LINE No. 6 (continued)

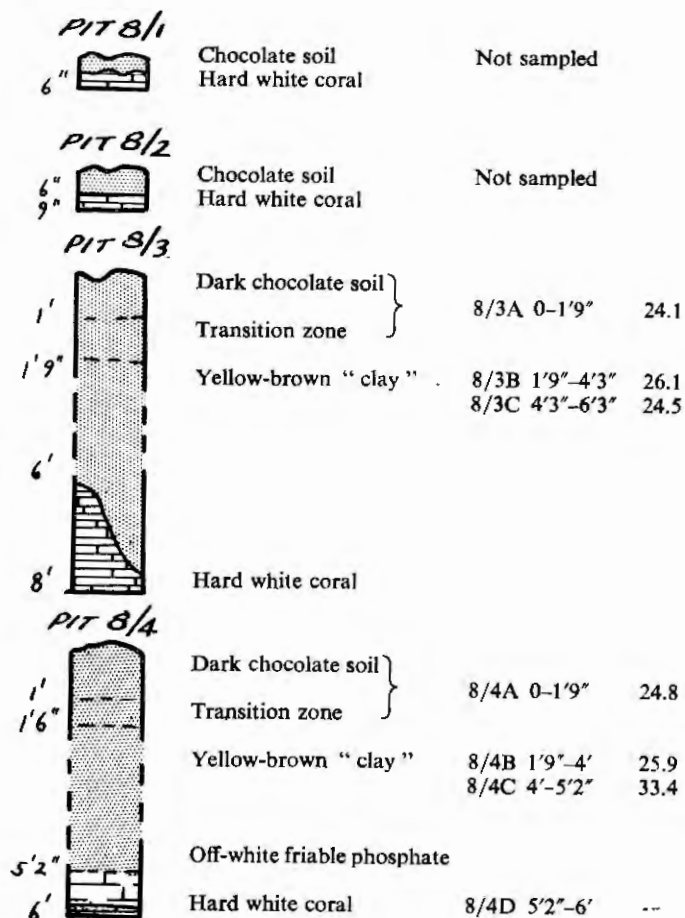
		Sample No. and depth	Assay P ₂ O ₅
PIT 6/8			
	Dark chocolate soil	6/8A 0-2'	22.1
2'	Yellow-brown "clay" containing soft white phosphate fragments (1/4"d) which become more numerous with depth	6/8B 2'-6'	28.6
6'	Yellow-brown incoherent phosphate	6/8C 6'-6'6"	34.2
7'	Soft chalky off-white material		
8'	Soft friable snow-white coral	6/8D 6'6"-8'	18.4
PIT 6/9			
1'5"	Dark chocolate soil	6/9A 0-1'1"	19.1
1'8"	Transition zone	6/9B 1'1"-3'	26.1
	Yellow-brown "clay"	6/9C 3'-6'3"	23.4
6'3"	Gradual change from clay to soft off-white phosphate	6/9D 6'3"-7'6"	35.6
7'	Soft chalky off-white phosphate	6/9E 7'6"-8'6"	—
8'	Hard white coral		
8'6"			
PIT 6/10			
	Dark chocolate soil		
1'4"	Transition zone	6/10A 0-1'6"	19.1
	Yellow-brown "clay"	6/10B 1'6"-4'3"	24.7
		6/10C 4'3"-6'2"	23.2
6'2"	Gradual change from "clay" to chalky off-white phosphate	6/10D 6'2"-7'5"	34.4
7'5"	Soft white phosphate becoming harder with depth	6/10E 7'5"-8'	37.9
8'			
9'			
PIT 6/11			
1'6"	Dark chocolate soil		
2'	Transition zone	6/11A 0-2'	20.0
	Yellow-brown "clay"	6/11B 2'-6'	19.7
		6/11C 6'-10'	22.0
11'	Yellow-brown "clay" containing scattered rounded black nodules (1/4"d)	6/11D 10'-14'	23.0
		6/11E 14'-18'	24.6
		6/11F 18'-22'	24.3
		6/11G 22'-26'	24.4
25'			
26'	Soft off-white phosphate		

		Sample No. and depth	Assay P ₂ O ₅
PIT 6/12			
1'	Dark chocolate soil	6/12A 0-1'2"	12.1
3'6"	Hard white coral	6/12B 1'2"-2'	0.4
LINE No. 7			
PIT 7/1			
6"	Dark chocolate soil		
1'	Hard white coral	Not sampled	
PIT 7/2			
1'4"	Dark chocolate soil		
1'6"	Transition zone	7/2A 0-1'6"	—
	Yellow-brown "clay"	7/2B 1'6"-3'6"	11.3
		7/2C 3'6"-5'6"	12.6
5'6"	Hard white coral		
PIT 7/3			
	Dark chocolate soil	7/3A 0-1'9"	20.8
1'9"	Transition zone	7/3B 1'9"-3'6"	—
3'6"	Yellow-brown "clay"	7/3C 3'6"-7'	25.0
		7/3D 7'-10'	25.2
		7/3E 10'-13'	25.1
16'	Soft off-white material	7/3F 13'-16'	17.8
PIT 7/4			
9'	Dark chocolate soil		
1'6"	Transition zone	7/4A 0-1'6"	25.4
	Yellow-brown "clay" containing scattered weathered fragments of coral (1/4"d)	7/4B 1'6"-4'2"	31.7
4'2"	Off-white soft friable phosphate	7/4C 4'2"-5'10"	35.1
5'7"	Hard white limestone		
7'			

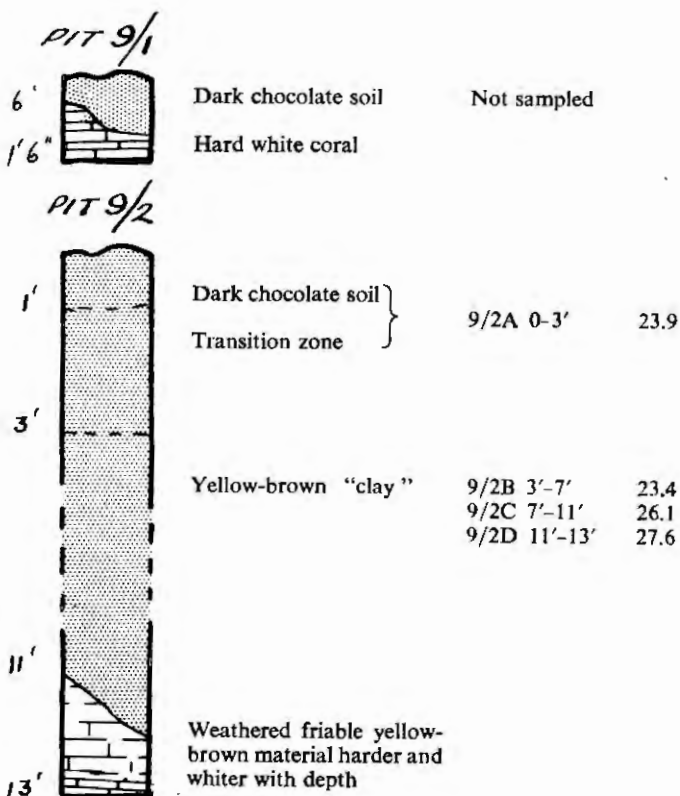
LINE No. 7 (continued)



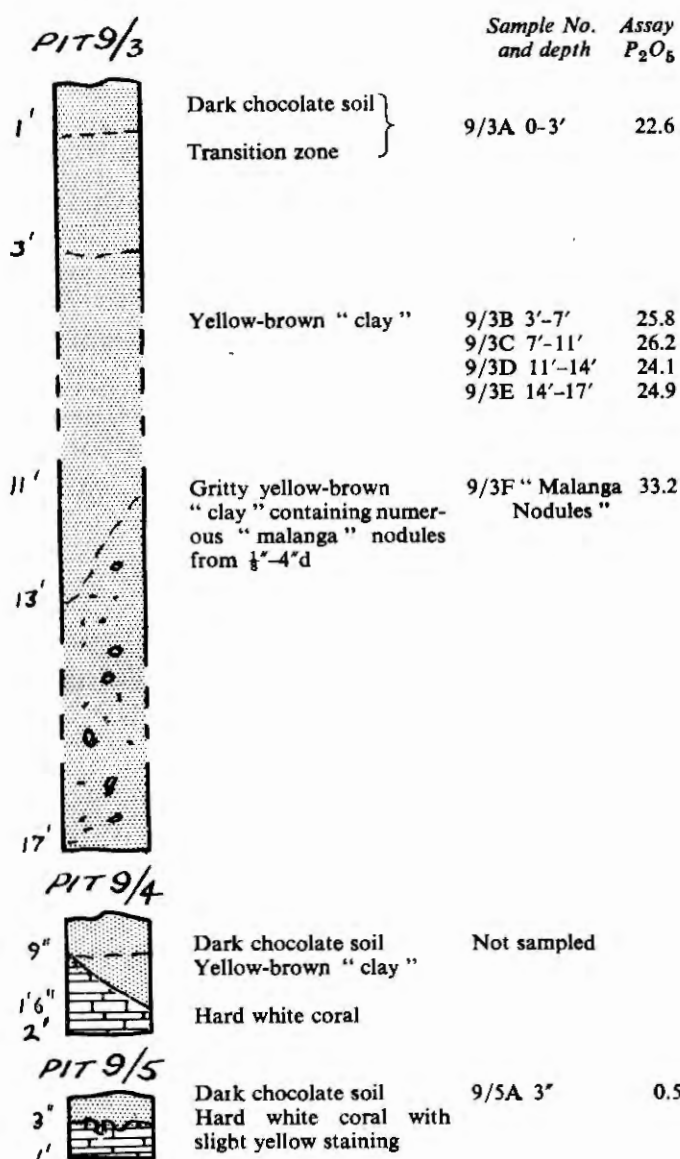
LINE No. 8



LINE No. 9



LINE No. 9 (continued)



(Assays by the Australian Bureau of Mineral Resources, Canberra)

Conclusion

The coral bedrock is irregular and has weathered into chimneys and funnels more usually than pinnacles and depressions. Some depressions exceeded 20 ft., filled with the yellow-brown rather clay-like* phosphates of

* But more porous.

alumina and iron oxides. Although unsuitable at present for the manufacture of superphosphate, this material might be useable in due course after research has shown the way. The deposit will probably be of economic interest in the future.

Limited quantities of off-white high-grade phosphate underly the ubiquitous yellow-brown low-grade material.

THE BEACH SANDS OF GUADALCANAL—NOTES ON J. W. CONNOLLY'S INVESTIGATIONS, 1957

By J. C. GROVER

In late October and early November, 1956, Mr. Connolly visited Guadalcanal on behalf of East Coast Minerals Pty. Ltd., of Sydney, and made a comprehensive collection of the beach sands of Guadalcanal. In this he was assisted by Clement Marau, a Geological Assistant of the Department, who accompanied the District Commissioner on a tour of the southern coast and collected samples en route.

magnetite, with minor quantities of other iron minerals such as haematite, chromite, ilmenite, etc. The non-magnetic fraction of the concentrate, which would carry any rutile or zircon values, usually comprised only a few grains of material out of the several ounces of concentrate—less than one per cent.

In all cases where slicks and seams of heavy mineral occurred naturally concentrated on the beaches, the

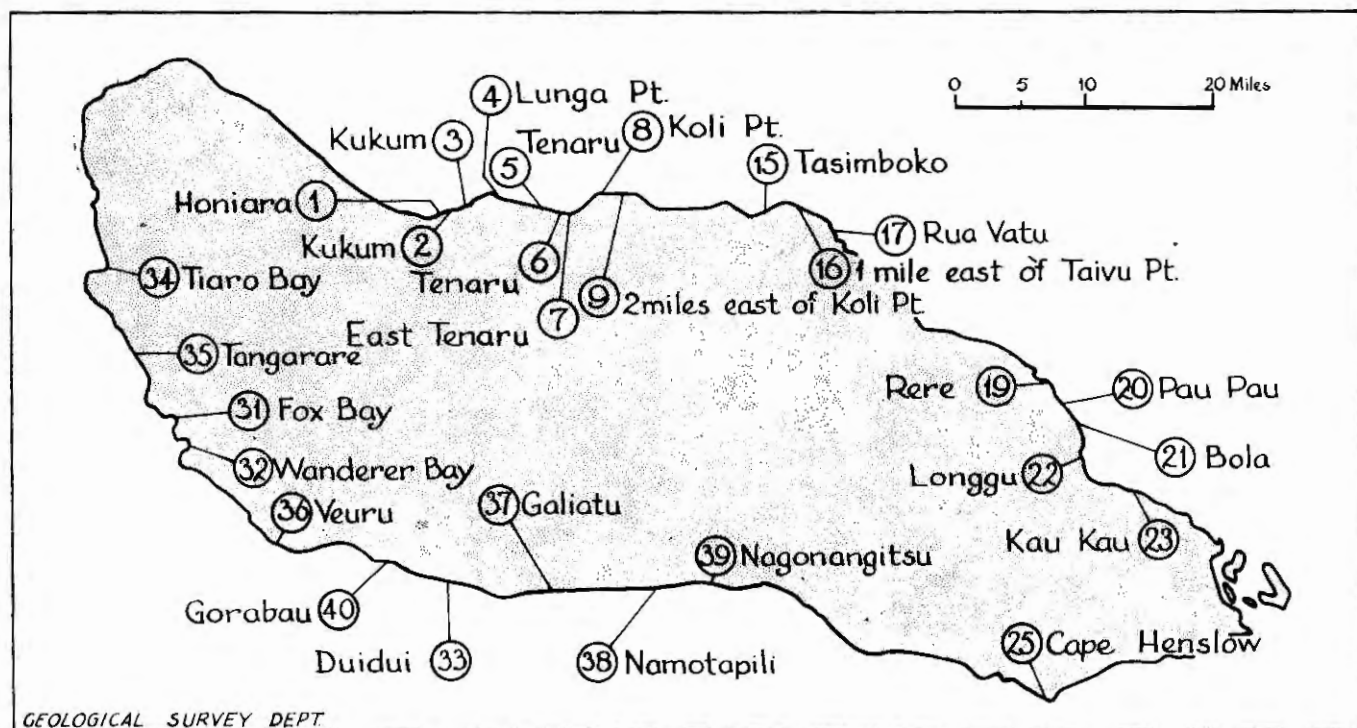


FIG. 19.—Location map for samples of Guadalcanal Beach Sands.

As a result of samples taken (see map), Mr. Connolly is of the opinion that there is no likelihood of payable deposits of rutile, zircon or monzonite being discovered. The reason for this is that whereas Australian sands are derived from acid igneous rocks, these rock types are almost absent in Guadalcanal. No granites have yet been located: the beach sands of Guadalcanal are derived almost entirely from basic and intermediate rock types.

The bulk of his samples (as well as others from Papua and New Guinea) showed the sands to be composed of ferromagnesian and other basic silicates such as hornblende, pyroxene, olivine, epidote, etc. Free silica in the form of quartz was conspicuously absent. Concentrates washed from sands were usually almost entirely of

material was of similar iron composition. As well as the dark-coloured basic beaches, many beaches composed of coral sand were seen. Beaches made up of washstones, shingle, and coarse gravel with practically no sand-sized material, were also encountered.

A colour of gold was detected in one sample (from Longgu, on the north coast) but two check samples failed to reveal any more; apart from this no gold (or metals of the platinum group) were found.

Most of the beaches were extremely narrow—about 10 ft. to 15 ft. being the average width. Likewise the beach material is only of shallow depth in most cases—rapidly giving way to layers of washstones. Forest invariably extends almost to the waterline and such conditions no doubt account in part for the lack of

development of large areas of dunes. However, in some areas raised strand lines are apparent behind the existing beaches, extending for some miles inland. Such areas, although overgrown, will probably prove to be of similar composition to the present beaches.

TABLE 1
BEACH SANDS OF GUADALCANAL

Sample No.	Location	Description	Remarks
1, 2	Honiara Hospital	Concentrations of HM on this beach up to 6 in. thick. HM consists of 90% magnetite plus other iron and iron silicate.	See remarks re magnetite in report.
3	Kukum	A gravel and grit beach poor in HM.	No value.
4	Lunga Point	A shallow washstone beach with very little HM.	No value.
5	Tenaru	Slicks of HM on beach—all magnetite.	No value.
6	Tenaru, Timber Mill.	A concentration similar to Honiara Hospital Beach. HM all magnetic.	See remarks re magnetite.
7	E. Tenaru	Picked seam concentrates of HM. Nearly all magnetite.	See remarks re magnetite.
8	Near Koli Point	A dark grey-green sand yielding a HM concentrate similar to No. 6 but containing a trace of zircon.	No value.
9	East of Koli Point	A grey-brown sand yielding a very little quantity of iron minerals.	No value.
15	Tasimboko	Sand containing very little HM of which all but a trace was magnetite. Non magnetics included a strong trace of zircon and 2 grains of rutile were noted.	Too poor to be of value.
16	Near Taivu Point	Sand contains very little HM, mainly magnetic with trace of zircon.	No value.
17	Rua Vatu	A big sandy beach but containing no appreciable quantity of HM.	No value.
19	Rere	A dark green sand containing quartz pebbles but only a trace of HM.	No value.
20	Pau Pau	No HM sand.	No value.
21	Bola	A few slicks of HM on beach but concentrates entirely magnetic.	No value.
22	Longgu	A grey-green sand containing only a very light trace of HM but first sample washed contained one colour of gold. Two check samples contained no gold.	No value.

Sample No.	Location	Description	Remarks
23	Kau Kau	A yellow coral sand containing no HM.	No value.
25	Cape Henslow	A long beach mainly of gravel and containing very little sand or HM.	No value.
39	Nagonangitsu	A fine light grey-green sand containing no appreciable amount of HM.	No value.
38	Namotapili Creek	A fine dark sand containing much HM consisting of 90% magnetite, remainder fully magnetic.	See general remarks on magnetite.
37	Galiatu	A dark grey-green sand to light gravel very poorly sorted, but containing a good proportion of black HM. Over 90% magnetite, remainder epidote and pyroxene.	No value, but see general remarks re magnetite.
33	Duidui	A fine dark brown-green sand, giving only a light trace of HM mainly magnetite and epidote, but one grain of rutile (?) noted under microscope.	No value.
40	Gorabau	A grey gravel containing much HM consisting of 90% magnetite, remainder fully magnetic.	No value.
36	Veuru	A dark brown unsorted grit containing very little HM consisting of much epidote and a little magnetite.	No value.
32	Wanderer Bay	A black sand nearly all HM about 90% magnetite other magnetics 9%, remainder includes a very light trace of zircon.	See remarks re magnetite
31	Fox Bay	A coarse sand containing much shell grit and no appreciable amount of HM.	No value.
35	Tangarare	A fine brownish-black sand containing fair quantity of HM consisting of 60% magnetite, remainder pyroxene and epidote.	No value.
34	Tiaro Bay	A fine dark sand containing much black HM about 85% magnetic with apparent light trace of rutile.	Rutile content less than 0.5% of HM. No value.

Mineralogical Examination by Mineral Resources Division, London

Duplicate check samples of Mr. Connolly's samples were sent to London for examination, as it was hoped that a mineralogical analysis might provide a clue to rock types found in areas which we had not yet explored.

All samples were checked and found to be non-radio-active. The five showing richest opaque mineral content were subjected to a detailed examination, with the following results :—

	Honiara Hospital No. 1	East Tenaru No. 5	East Tenaru No. 7	Wanderer Bay No. 32	Namotapili Creek No. 38
Magnetite %	52	77	81	68	72
Low Magnetic Opaques %		3	9	10	
Quartz Calcite & Labradorite % ..	10	3	3	3	
Hornblende %	12	2	2*		
Pyroxene %	24	12	5	12	
Rock Fragments %	2	3		4	28
Hypersthene %				3	

* This figure also includes a small amount of zircon.

Fractions of Samples 5 (East Tenaru) and 32 (Wanderer Bay) were examined further, with the following results :—

Total Fe as	Magnetic Portion		Methylene Iodide
	Sample 5	Sample 32	Sink Sample 32
Fe ₂ O ₃ %	89.0	80.4	
TiO ₂ %	6.8	9.9	6.2
Cr ₂ O ₃ %		0.9	7.0

Chromite was proved in Sample 32, while the titanium in both samples was probably derived from magnetite —as no ilmenite could be proved.

Conclusions

The sands collected are of little economic importance, but the possibilities of economic deposits must not be considered to have been exhausted, as there are black sand beaches in other places besides those sampled.

THE BEACH SANDS OF THE WEST COAST OF SANTA YSABEL, 1957

By J. W. CONNOLLY (East Coast Minerals Pty. Ltd.)

From March 29th to April 7th I inspected the coastline of Santa Ysabel Island for economic iron-chromite beach deposits.

First attention was given to the beach at Lithogohira Bay, which was the principal beach referred to my attention by the Chief Geologist, Mr. Grover. Three days were spent surveying and boring this beach.

On first landing near Lithogohira River mouth it was seen that the beach carried a good deal of black heavy mineral, seams 6 in. thick being visible in this vicinity. A survey showed that the sandy portion of the beach was 114.8 chains in length, or just under $1\frac{1}{2}$ miles, but that the sand was confined to the tidal area and a single frontal dune of up to 12 ft. in height above water-mark. This dune averaged only one chain in width along most of the beach, behind which it fell away into a mud and clay swamp. It was realised that a considerable depth of sand carrying values would be required to get any workable tonnage.

A grab sample from a surface seam near the river mouth contained 64% magnetite plus a 30% residue of heavy mineral mainly consisting of pyroxene. A representative sample of all residues has been retained for chromite assays.

The first borehole sited west of the river mouth passed through sand carrying good magnetite values for 6 ft., after which gravels came in, rapidly becoming coarser and carrying very little mineral. This hole averaged 9% magnetite through 12 ft.

The second hole, located 10 chains further west, repeated the same pattern, and averaged 16% magnetite through 10 ft. depth. A third hole, five chains further west, averaged 28% magnetite through 8 ft. depth. It was apparent while boring these three holes that the main values were confined to the top 5 ft. of sand-sized particles: two holes put down across the width of the dune at chain intervals confirmed that the top layer of

sand was averaging about one-third magnetite, these holes yielding, respectively, 36% and 30% for 5 ft. before passing into poor gravel.

Boreholes at 20 chains and 25 chains west of the river through the sand layer averaged 20% and 15% magnetite, indicating a falling off in value as distance from the river mouth, down which the magnetite is constantly being transported, is increased.

Two boreholes sited five and 10 chains along the shorter section of beach east of the river both averaged 12% magnetite, which was comparatively poor compared with the values to the west.

Conclusions on Lithogohira Bay Beach

1. Magnetite values are confined to a strip of sand 114.8 chains long, $1\frac{1}{2}$ chains wide (including tidal area) and average maximum depth of 6 ft., which is equivalent to 166,600 cubic yards of material.

2. Average values over the full length, allowing for decrease as distance from river mouth is increased, would not exceed 16% magnetite, equivalent to 446 lb. magnetite per cubic yard of material.

3. The beach contains only 9,228 tons of magnetite, and even if residue samples show considerable chromite, the tonnage is too small to warrant working.

Other Santa Ysabel Beaches

As Lithogohira was the principal mineral beach it was realised that little could be expected from other beaches, and this proved to be the case. Beaches at Samusodo, Korigoli and Susubona were sampled. All carried magnetite values in disseminated form, but important concentrations were lacking. During the time spent on the island most of the coastline was examined in daylight at close range but singly or collectively no worthwhile mining property could be made from these beaches.



FIG. 20.—Sketch map of Santa Ysabel showing beach sand locations.

REPORT No. 14

THE CAPE HENSLOW IRON FORMATION ON GUADALCANAL, 1957

By J. W. CONNOLLY (East Coast Minerals Pty. Ltd.)

An American Army reconnaissance party reported the presence of siliceous haematite and limonite over a horizontal extent of $1\frac{1}{2}$ miles and about 1,000 ft. thick as was briefly recorded in Chapter XXXI of Grover (1955). A traverse between Oa and Korai gave the section which Mr. Grover reported.

I sailed with an assistant (Mr. Murray) to Cape Henslow, and made camp at Oa Village, near the now-deserted site of Onesere. Over the course of a week's prospecting in which over 40 miles were covered in steep jungle country, we combed the area along the course of the traverse across the high ground, and located the

the severe tropical weathering cycle of alternate heavy rainfall and high temperatures, the slopes of the spur are covered with thick soil and jungle vegetation; the country rock is exposed in the steep water-courses and as boulders scattered through the soil. All this float material is very decomposed, and when broken invariably displays the appearance of limonite (yellow iron oxide). No doubt analysis would reveal a substantial iron content but it is doubtful if it would exceed the range of 25 to 35% metallic iron. In addition, all the large boulders retain an unaltered core of dark igneous rock, and there is no doubt at all in my mind that the formations referred to by the Americans are merely a surface-weathered mantle of decomposing iron-rich igneous rock. Such conditions are by no means uncommon in the tropics and in this instance their rather distinctive yellow, and in places red and brown, coloration has led to their being plotted as haematite and limonite. Both these minerals often occur as earthy varieties, but in this case the material is not up to ore grade.

I brought back many samples from this area, and Geologist Pudsey-Dawson, then in charge at Honiara, was in agreement with my interpretation of their nature and origin.

Conclusions

The formation described by the Americans was located and while extensively exposed, must be regarded as superficial in its nature of occurrence, and too low grade in iron content to warrant working on any scale.

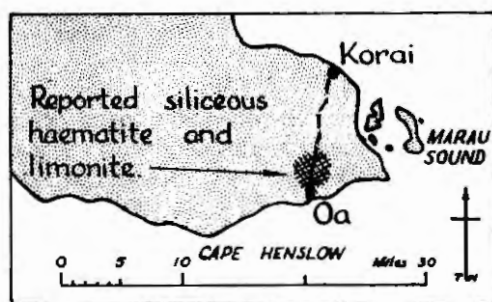


FIG. 21.—Sketch map of eastern Guadalcanal.

formations which coincided in position with the American report. These formations occur on a large spur of up to 2,000 ft. in height running between Marau Peak and an unnamed peak to the west. As a result of

ILMENITE AND GARNET CONCENTRATES IN THE KWAI HARBOUR AREA OF EAST MALAITA, 1958

By P. A. PUDSEY-DAWSON

In November 1958 the major rivers and their tributaries in the Kwai Harbour area of east Malaita were visited for a week, following up the work of Mr. Grover in June 1956, when ilmenite and gem gravels were found in the headwaters of the Auluta River on the northern flank of the Kwai Anticline.

Folded limestones, silts and calcareous sediments of the Malaita series crop out over the greater part of the area, but inliers of the Alite Volcanics are found exposed along the axis of the Kwai Anticline at the headwaters of the Auluta River, and along the axis of the Alite Anticline in the Kwaibeta Valley further south.

Ilmenite was found in varying amounts in most rivers that drained from areas of Alite Volcanics, but was almost absent in the Kwaibeta headwaters and the Kwakware River. Washed concentrates show the ilmenite grains to be about 1 mm. in size, but 3 mm. crystals were picked up on the track near the Kwaiafa River. (Specimens collected by Mr. Grover in 1956 in the Taba'a-Lami area were 1 cm. and more in size.) Many of the crystals have a lustrous appearance and are notably rounded in form, while others are dull and have undergone abrasion; breaking of the individual grains

by attrition probably accounts for the smaller particle size in the lower reaches of the river.

The actual source of the ilmenite has still not been found. Streams which come from areas of the normal fine-grained and massive lavas and flows show little indication of ilmenite or other concentrates, and the sands consist of broken fragments of rock rather than individually-separated and washed crystals.

Samples of the concentrates were sent to the Mineral Resources Division of the Overseas Geological Surveys in London for examination, and the report may be found in Appendix D.

Although present in most of the rivers draining from outcrop areas of the volcanics, the ilmenite does not appear to be in really great abundance except on the beach at the mouth of the Kwaibeta River. Here a wide beach of black sand extends for about $\frac{3}{4}$ mile between the two headlands, derived from the Abasi River and elsewhere and concentrated by wave action.

The ilmenite-bearing gravels in the Kwaiafa River may well be worth further attention and evaluation. The ilmenite here is of small grain size, and makes up about 50% of the washed concentrate. Larger grains are found

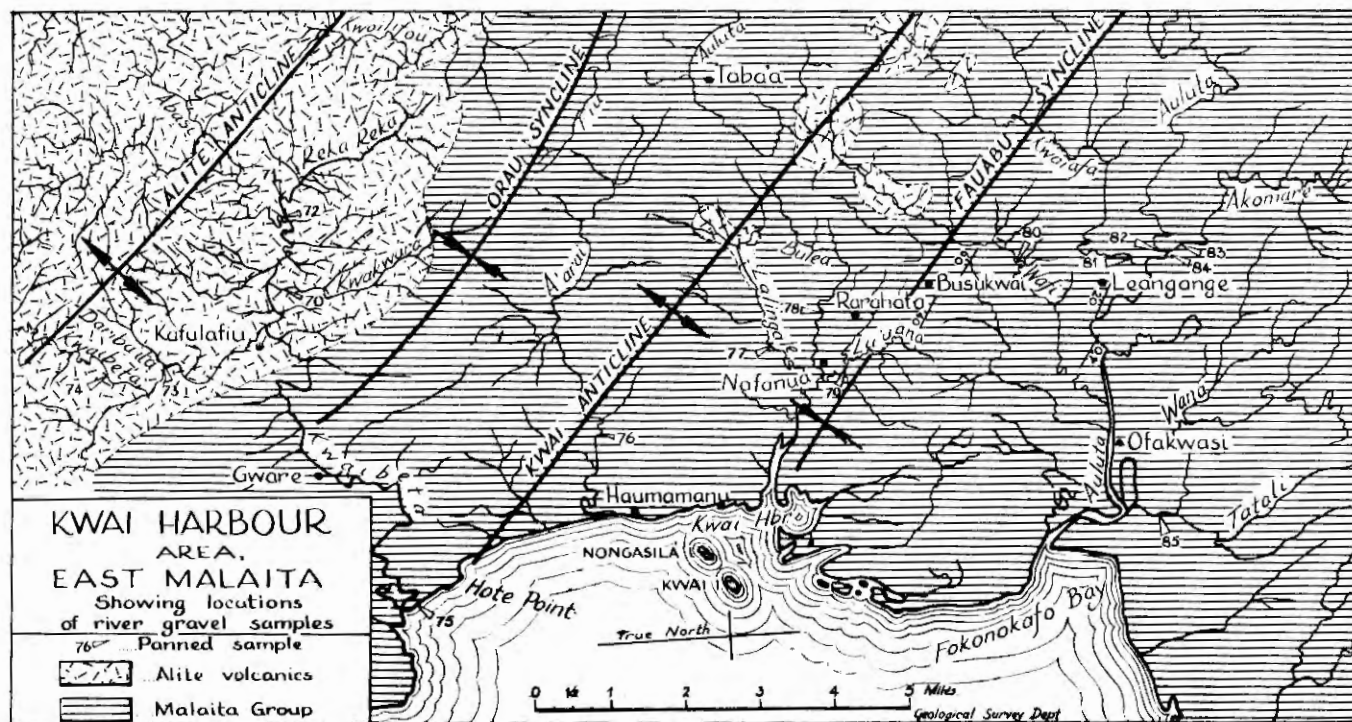


FIG. 22.

less frequently. Pyrope garnet is present in a significant amount (approximately 15% to 20% of washed concentrates) with grain sizes up to 4 mm. of irregular form with no true crystal shape, translucent and red to pink in colour*.

No deep pits were dug because of shortage of time, so we have no information as to what will be found at depth. The area was in low-lying ground with few rock outcrops; the gravels seem to be of considerable extent, and are readily accessible from the coast. Unlike

* They were identified by X-ray analysis at M.R.D., London, in 1956. See Memoir No. 2, Chapter XX.

many other neighbouring rivers, the sands in the Kwaiafa were relatively clean and sharp concentrates, unusually rich in ilmenite and garnet. No concentrations were noticed on Fokonokafo Beach at the mouth of the Auluta River.

Conclusions

Ilmenite is present in considerable quantity. Pyrope garnet occurs in unusual abundance in the Kwaiafa River gravels. The area is readily accessible from the coast, and a good anchorage is near at hand at Kwai Harbour.

NOTES ON THE ISLANDS OF RAMOS (ANOGO), GOWER (NDAI) AND BASAKANA, 1958

By J. C. GROVER

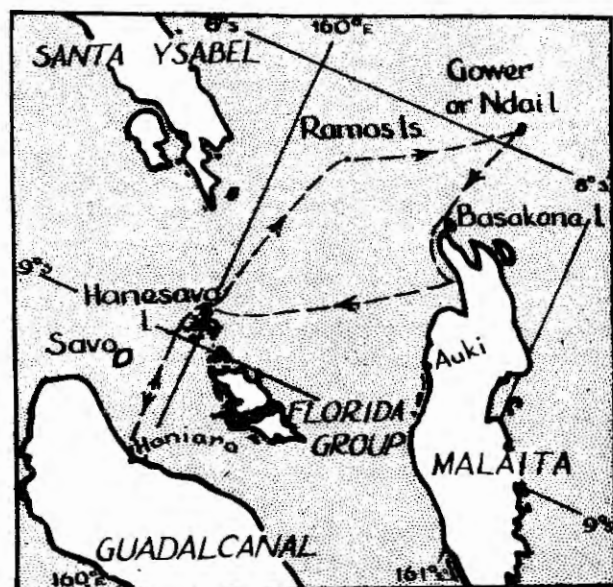


FIG. 23.—Map showing Islands visited.

Brief reconnaissance visits were paid to these islands in February 1958. Very little time was spent on each island owing to the necessity for the ship to return promptly for other duties.

The sea was calm during the trip, but between Hanesavo and Ramos a most disturbing wave-interference motion became apparent at the place where the bathy-

metric chart showed the fall to the deeper tectonic basin, and again where the submarine anticline was crossed (the 600-fathom seabed closed contour). This was most notable, although there was no wind and nothing in the nature of a tide rip was apparent.

Ramos

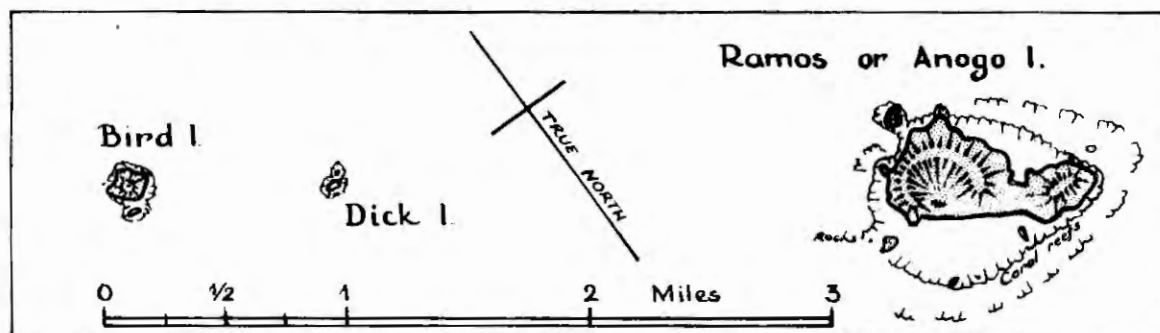
We anchored in the lee of Ramos after sunset, 1900/5, and disturbed seemingly millions of frigate birds, which became airborne in the gathering darkness.

A short visit was made ashore by the light of the brilliant full moon, and the classic structures of the ubiquitous basaltic and doleritic pillow lavas were seen. It was not possible to leave the shoreline and climb inland on this occasion, and we sailed at 0200/5. However, the island had recently been visited by Messrs. Thompson and Latter, so it was not considered important enough to delay for a day: being closest to the main island of Ysabel it will be easiest to visit in the future.

It seems from the profiles that all of these Ramos islands are of basaltic pillow lavas. They lie along the crest of a submarine anticline which plunges towards the deeper "subsidiary" trench* between Ramos and the northern end of Malaita.

The main island is about half a mile long by a quarter of a mile maximum width, and fringed by a reef on the north and south sides, within whose bounds stand several

* Refer to "A Regional Picture of the central Solomons" Chap. VIII of Memoir No. 2 (1958).



FIGS. 24 and 25.—Map of Ramos Islets and Profile Sketch of View from the south-west

smaller islets : there is not much reef on the eastern and western ends. Deeper parts of the reef permit small ships to anchor with reasonable safety, and provide excellent fishing. We landed a tuna weighing at least 40 lb. as we came in.

To the westward, a little over $1\frac{1}{2}$ miles distant, are two double pinnacles, apparently rising from fairly deep water : they have no fringing reefs.

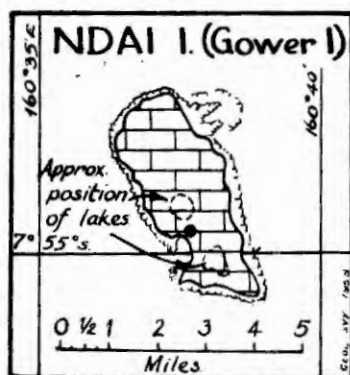


FIG. 26.—Map of Ndai (Gower) Island.

Gower, or Ndai, Island

Gower was reached at 0815/5, and we anchored in the pleasant bay on the west side of the island, where there are two low-standard villages with about 80 people. I was informed that the area is mosquito-infested, and that

in the evenings clouds of mosquitoes invade the ships at anchor in the bay.

The island is entirely of recently-emerged coral limestone, flat and low-lying, with swampy areas, and at least two lakes, one-time lagoons. One of these is connected to the sea by a hand-dug canal.

Leaving Gower Island at 1100/5, we reached Maluu Harbour at 1615/5.

Basakana Island

Next morning we went ashore on nearby Basakana Island for one hour, during which we walked to the central part of it.

On the mainland side of the island is an extensive crescent-shaped area of emerged sand beach country, on which is situated the village area, with gardens immediately inland. The main island platform is of higher-level emerged coral limestone, oval-shaped, about a mile long, bounded by cliffs (except on the mainland side) and a fringing reef platform about 200–250 yards wide. Although a report had been received of soil resembling that of Bellona, no sign of any phosphate was seen. The soil cover and laterite was of no great thickness, and coral rock was exposed in the centre of the island.

Conclusion

No signs of phosphate were observed on any of the islands visited.



PLATE VI

Old coral remnant and growing coral at low tide in the anchorage bay on Ndai.



PLATE VII

The trap for leaping fish at the canal entrance to the lake, with brush wall on both sides to narrow the passage to net width. This picture was taken at low tide : at high tide the water covers this low-lying ground, covered mostly by pandanus vegetation.

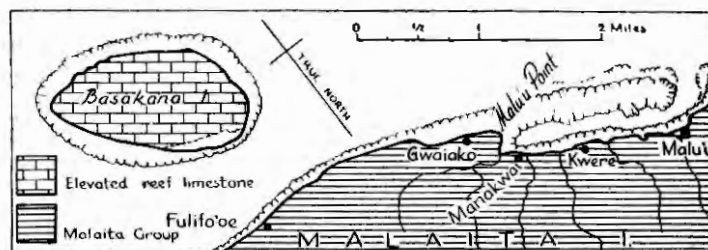


FIG. 27.—Basakana Island, off the North Malaita coast.



PLATE IX

Showing method of working : geologist recording readings ; surveyed grid area in background where tall grass has been cut down. Guadalcanal on the horizon.



PLATE X

The portable proton precession magnetometer showing its component parts (and avometer for testing).

FURTHER EXPLORATION OF HANESAVO, 1958

By J. H. HILL

Introduction

Hanesavo Island lies 36 miles north of Honiara, at the western end of the Florida Group: roughly triangular, with sides just under $1\frac{1}{2}$ miles in length, it is approximately $1\frac{1}{4}$ square miles in area.

Coral reefs fringe the coast, with two gaps leading to steep sand-beaches, one near Seu Island and the other south of the narrows between Hanesavo and Buena Vista, where an all-weather safe anchorage is possible.

are areas of coral debris and hill talus up to 300 ft. wide, half a mile long, a few feet above sea level. Some areas are swampy in wet weather.

The Chief Geologist carried out a short pitting programme in 1951 (see Memoir No. 1) when manganese was exposed on both sides of a grassy hill a few hundred yards north of the anchorage. The work dealt with in this report was done during the first quarter of 1958,



PLATE XI

Shipping can tie up close to the beach near the deposit. Below low-tide mark, just visible in this photograph, the sandy bottom drops steeply away.

There is no settled native population, but the island is regularly visited by the local people, who have gardens and coconuts situated along the northern and eastern coasts. Elsewhere there are mangroves, secondary bush and grass on the higher parts of the steep hill slopes, which rise 200 to 250 ft. The highest is at 380 ft.

Along the coastline between the beaches and the hills

when an extensive pitting programme was completed around the manganese prospect and the island was mapped to a scale of 6 in. to 1 mile. A proton magnetometer survey was subsequently made. The area was again examined in May and June 1958 by Dr. Phipps, of Sydney University, on behalf of a company which had been granted a Prospecting Licence.

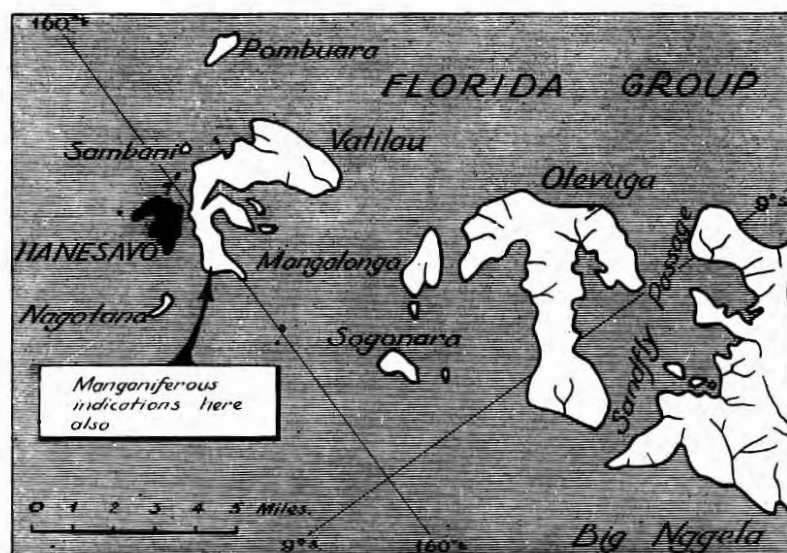


FIG. 28.—Map of the Florida Group showing position of Hanesavo.

Tectonics and Structure

Hanesavo is composed of a faulted succession of lavas, pyroclastics and sediments in which the majority of shears and lineations strike between 350° and 10° and dip between 35° and 60° to the east. Repeated faulting shows down-thrown sides to the east. It is possible that the western coast of Buena Vista is a fault line, as it is roughly parallel to the fault lines on Hanesavo.

The Manganese-bearing Lavas

The most ancient rocks are ironstained manganiferous lavas (spec. 3359, 3361, 3374) exposed around the manganese deposit near the centre of the island, and carrying irregular veinlets of manganese dioxide about half an inch wide and a few inches long.

Pillow Lavas

The ancient lavas suffered erosion before being covered by pillow lavas, which crop out over most of the low-lying areas below 50 ft. altitude. On the western side of the manganese deposit and in the vicinity of Pillow Lava Point they crop out at 100 ft. above sea level. The lavas are fine-grained greenish-grey and amygdaloidal (spec. 3349, 3346, 3370, 3386) and are soft and weathered in the vicinity of the manganese deposit. Amygdales are of calcite, zeolites and chlorite varying between one-sixteenth and one-eighth of an inch across. The pillows are normally between 12 in. and 24 in. across and surrounded by a weathered clay shell about 3 in. thick. They seem to underlie the island, subsequently having been blanketed by more recent lava flows.

Shales

Black lacustrine (?) shales (spec. 3365, 3367, 3371, 3394), not more than a few feet thick, were deposited on the weathered pillow lava surface and are invariably underlain by a few inches of manganese dioxide in irregular veinlets in the underlying lavas. The shales are

exposed at several places around the manganese deposit close to the 110 ft. contour where they appear to dip into the hillside and underlie tongues of ore, except in one place.

Younger Lavas

Fresh outpourings of lava, under sub-aerial conditions, covered these shales and the MnO_2 . The younger lavas are fine-grained, greenish-grey (spec. 3351, 3368, 3375, 3393) and contain zeolites, chlorite and calcite in the more amygdaloidal parts of the lava; some parts are highly amygdaloidal, others less. Calcite veinlets are scattered throughout the lavas, weathered to soft fragmental buff-coloured rock. Chert fragments lie along the nearby ridges, 300 yards west of the harbour camp site.

Fragmental Lavas

Pyroclastics are exposed occasionally. In excavation 21 (M.R. 930630) these are leached (spec. 3382) and lie on an eroded pillow lava surface; 200 yards to the south-south-east in excavation 39 (M.R. 590350) ironstained manganese-bearing lavas have been exposed containing sub-rounded ironstained lava fragments from $\frac{1}{2}$ in. to 6 in. across, loosely held in a gritty groundmass. Along the ridge towards Pillow Lava Point are a few hundred square feet of hard ironstained agglomerate (spec. 3350) composed of sub-rounded to sub-angular greenish-grey lava fragments $\frac{1}{8}$ in. to $1\frac{1}{2}$ in. across, firmly held in a fine-grained fragmental groundmass. A line of fault breccia striking 10° is exposed immediately west of this outcrop, and it is probable that the agglomerate lies on the down-thrown side. The surrounding country rock is of greenish-grey amygdaloidal lava.

Volcanic Neck

A 50-ft. wide volcanic neck of dense, fine-grained olivine-bearing basalt (spec. 3353) is exposed on the ridge 300 yards east of the above-mentioned agglomerate.

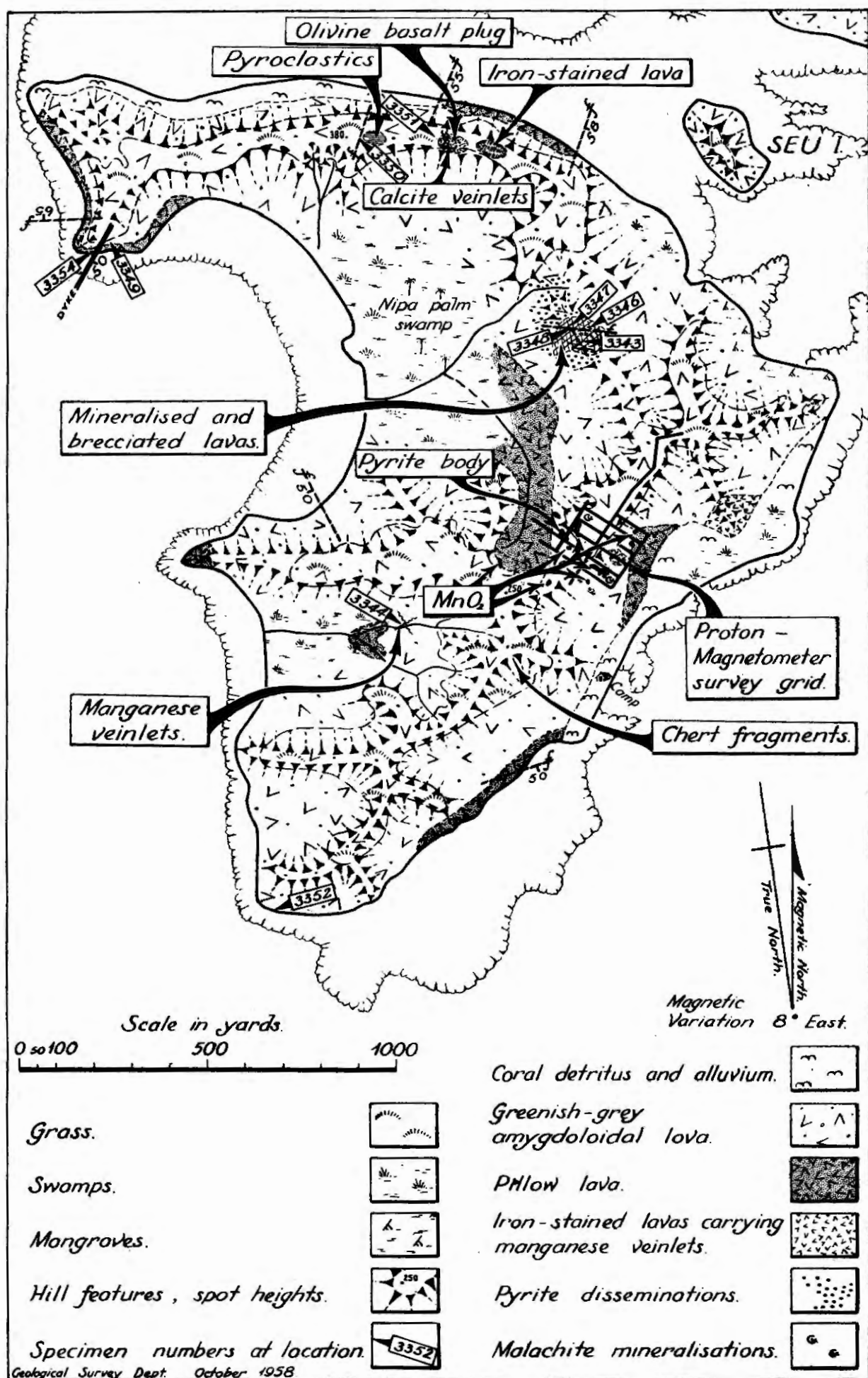


FIG. 29.—Sketch Geological Map of Hanesavo.

Ore Mineralisation

Situated near the centre of the island and in line with two of the low-lying areas back from the north-east and south-west coast lines is a roughly circular area of brecciated ironstained lavas extending 150 yards from east to west and 100 yards from north to south. Brick-red soil covers the southern and western slopes of the ridge and pyrite disseminations and crystal aggregates a few millimetres across occur in the slightly altered greenish-grey amygdaloidal lavas (spec. 3345, 3356, 3358) surrounding the main zone of alteration. A line of hard ironstained intensely brecciated rock (spec. 3346, 3347) 10 ft. to 20 ft. wide extends from east to west across the altered lavas. A shorter line of breccia branches at right angles from the western end of this feature. At the southern end of this shorter line the rocks are coated with red and yellow oxides of iron (spec. 3343). The breccia, the abundant iron staining, the brick red soils and disseminated pyrite in the altered lavas suggest mineralisation worthy of investigation*.

thinning to a few feet some 350 ft. distant to the north-west.

The main body of manganese dioxide lies on or above an old erosion surface between the older pillow lavas and the overlying greenish-grey amygdaloidal lavas. This surface keeps close to the 100-ft. contour except at the north-east end of the deposit, where a concealed fault which strikes roughly north-north-west has dropped the contact 50 ft. to the east.

At various places around the slopes of the manganese deposit, and directly underlying the manganese lenses and replacement bodies, are numbers of isolated outcrops of an ironstained lava carrying short irregular veinlets of psilomelane; it is these lavas which appear to be the source of the manganese.

Lying at the contact between the older and younger lavas, and immediately above the lenses of manganese dioxide, are narrow bands of dark chocolate to black manganiferous shales dipping into the rising ground on both sides of the deposit. The attitude of these beds is

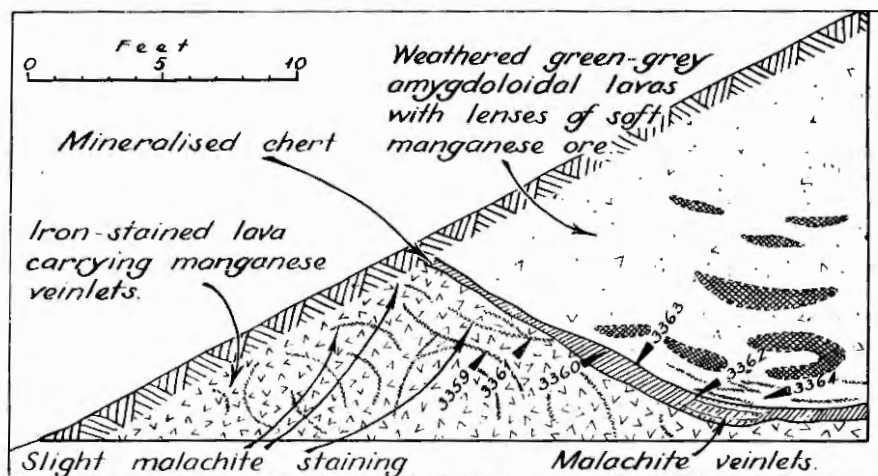


FIG. 30.—Excavation 16 (M.R. 770490). Section of western wall of trench showing manganese-bearing lavas, and the upper lavas containing manganese replacements.

The small islands of Seu and Borogohi and the double island of Nagotanga and Koronakaili are composed of greenish-grey amygdaloidal lavas. In the south-west corner of Buena Vista dense black manganiferous shale fragments (spec. 3376, 3377) were found in the valleys with lava fragments similar to those overlying the manganese on Hanesavo.

The Manganese Deposit

The manganese crops out on the slopes of a steep grassy and bush-covered ridge, between 100 ft. and 130 ft. high, about 400 yards north of the camp site and anchorage. It covers an area of $3\frac{1}{2}$ acres, and appears to be a lenticular concentrated body 25 ft. thick in the south-east and

probably due to the movement of the concentrations of manganese within the hill under the influence of gravity.

The shales are usually shattered, indicating differential movement along the contact between the upper and lower lavas. Before the upper lavas covered the shales the latter had been so extensively eroded that in many places around the deposit the upper lavas rest directly on the older pillow lavas.

Bands of brown siliceous material lie on the contact between the upper and lower lavas and are generally closely associated with manganese replacements. In excavations 11, 12, 14 and 15 (M.R. 560700) and at the base of excavation 4 (M.R. 730430) siliceous gossan carrying gold and silver values (Memoir No. 1) underlies the manganese and is apparently several feet thick.

* Refer to Report No. 19.



PLATE XII

Chocolate shales in distinctive bands up to two feet thick, invariably gently dipping, and on the 100-ft. contour or thereabouts suggesting one-time lacustrine conditions existing before the extrusion of the younger lavas. The shales invariably indicate veins and lenses of MnO_2 in the lavas adjoining.

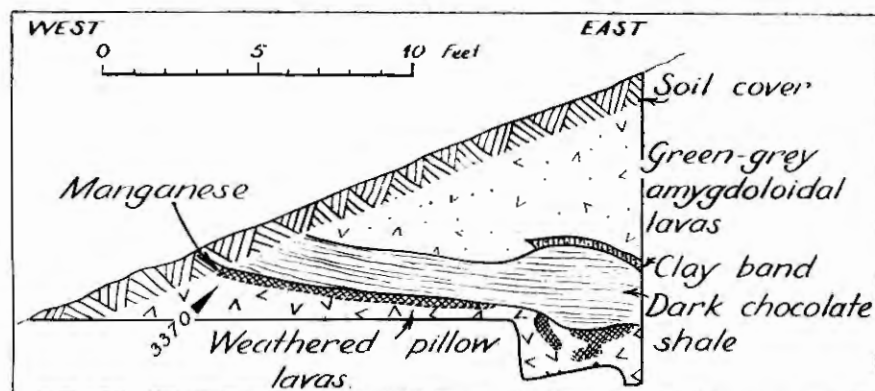


FIG. 31.—Excavation 26 (M.R. 300490) section of northern wall of trench showing contact between shale, manganese and lavas.

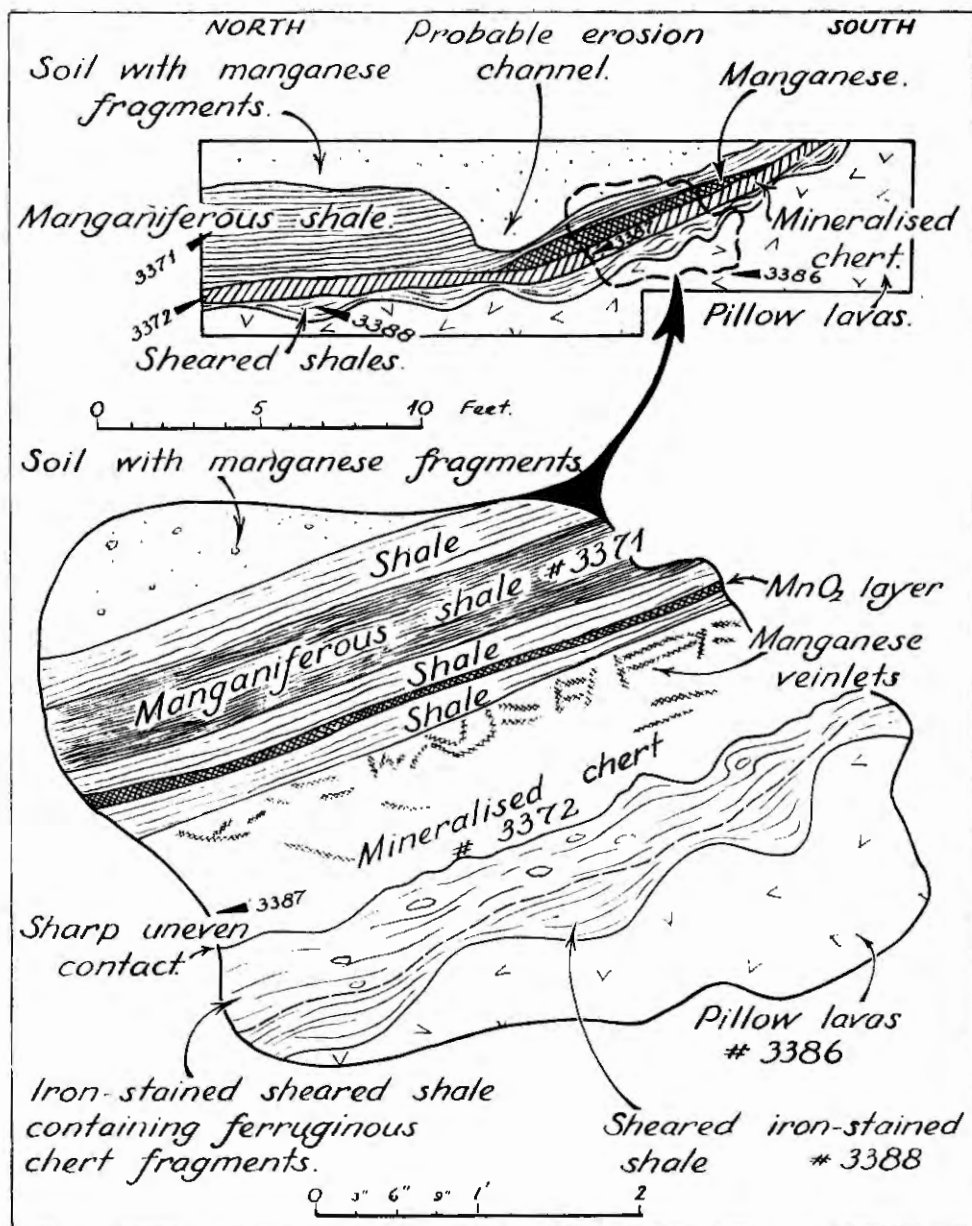


FIG. 32.—Excavation 29 (M.R. 380900). Section of eastern wall of trench showing shales, siliceous gossan, manganese and lavas.

The 25-ft. thick replacement body of manganese dioxide in the vicinity of the adit (M.R. 700450) is not overlain by shales but passes into a band of weathered clay a few inches thick; and then into the overlying greenish-grey amygdaloidal lavas which have weathered to a buff fragmental clay-like material, soft and easily excavated along with the manganese. The contact between the manganese and overlying lavas is undulating and gradually rises into the hill.

Mineralogy and Composition

The manganese ore consists of mainly soft earthy pyrolusite containing isolated patches of hard ferruginous

ore. Small hard fragments of psilomelane containing aggregates of pyrolusite crystals were found in the vicinity of the manganese-bearing lavas a few hundred yards north-east of the main deposit. Scattered quartz veinlets pass through the pyrolusite in rare places, rendering the ore hard and splintery. Generally speaking, however, the ore is soft, easily worked and readily amenable to hand sorting.

Origin of the Deposit

The primary source of the manganese is an iron-stained manganese-bearing lava which was covered by pillow lavas after a period of erosion. Shales were even-



PLATE XIII

Entrance to the adit (M.R. 700450). Contact between the manganese ore and the overlying weathered lavas can be seen low on the left-hand wall of the trench.

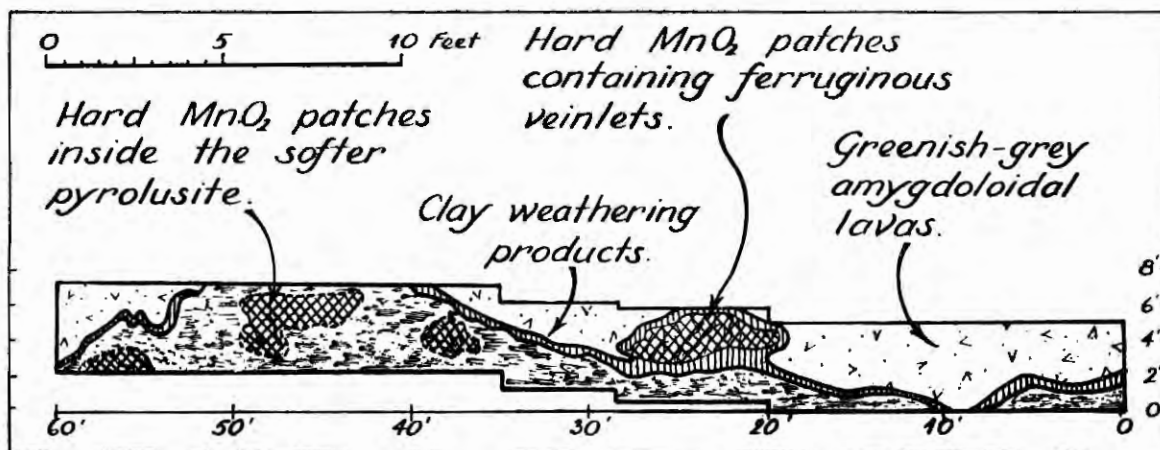


FIG. 33.—Section of north wall of adit on the eastern side of the deposit (M.R. 700450) showing contact between manganese and upper lavas.

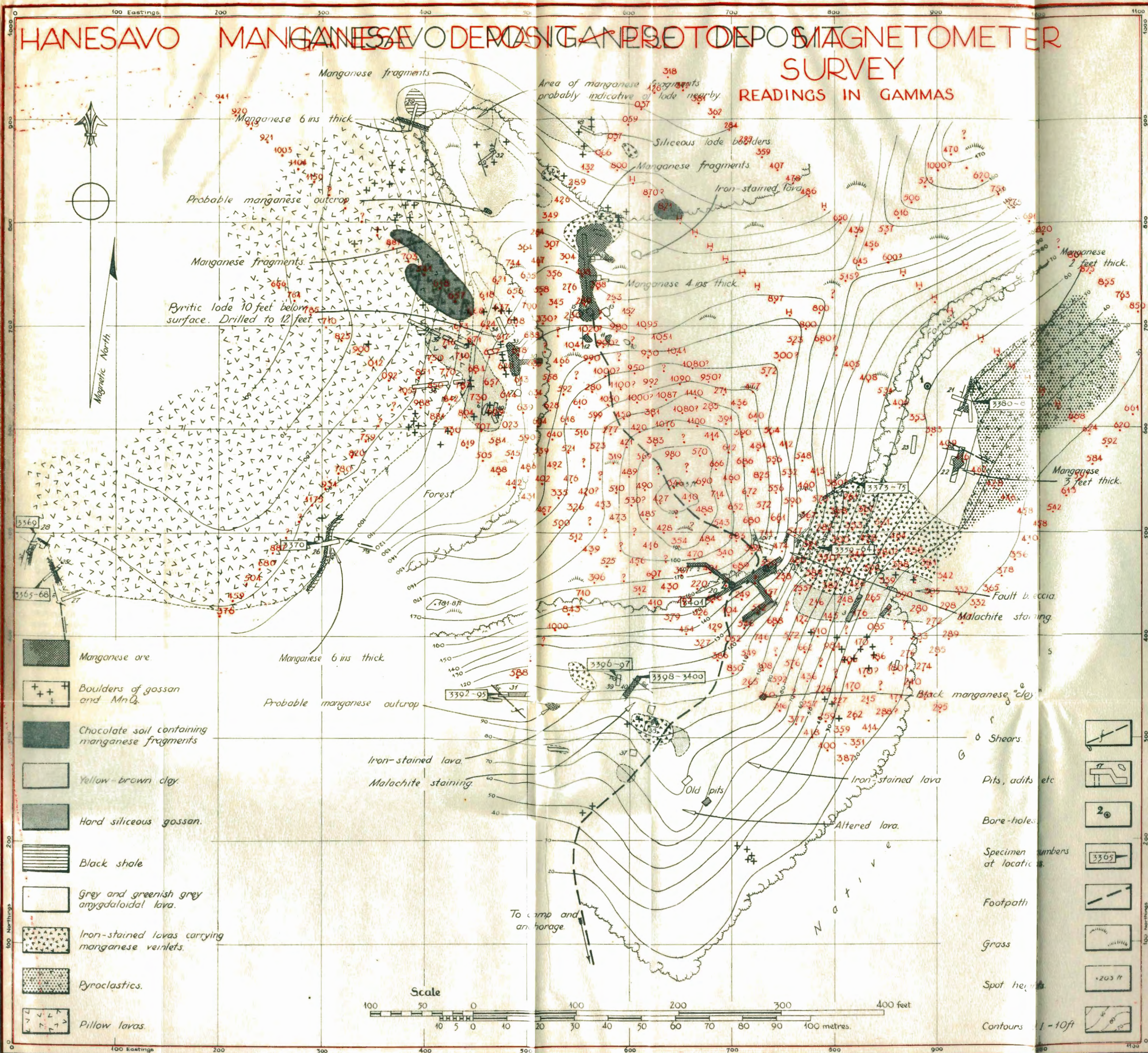
tually laid down under lacustrine conditions. It was probably immediately after this period of sedimentation that the siliceous bands containing the replacement veinlets of manganese were formed.

Subsequently fresh outpourings of lava covered the shales, this time under sub-aerial conditions, and it is in these lavas that the bulk of the manganese is concentrated. The manganese was leached from the manganiferous lavas and migrated into the upper lavas at lower levels on the hillside, at the same time enriching the shales. The main replacement body appears to lie some distance above the old erosion surface and is separated from it by a layer of brown siliceous material several feet thick. The manganese has been reconcentrated beneath the shales, usually as a band a few inches thick, and from here the manganese has replaced the underlying and overlying lavas as small scattered veinlets. Many of the

manganese dioxide concentrations in the upper lavas have been formed by gravitational movement of the original manganese dioxide bodies and intra-formational slumping of the lavas. This would help explain the erratic distribution of many of the concentrations.

Malachite and azurite veinlets and films are scattered throughout the lavas lying beneath the manganese, in the siliceous gossan and in the manganese replacements adjoining the gossan. In excavation 16 (M.R. 770490) the band of gossan between the upper and lower lavas contains a system of reticulating malachite veinlets.

An irregular body of pyrite, striking north-west and outcropping 10 ft. below the surface of the upper lavas, was found by Mr. Pudsey-Dawson in the first quarter of 1958. Report No. 19 of this Geological Record describes this feature.



Compiled by the B.S.P. Geological Survey Department from surveys by J.C. Brown and J.H. Hill.

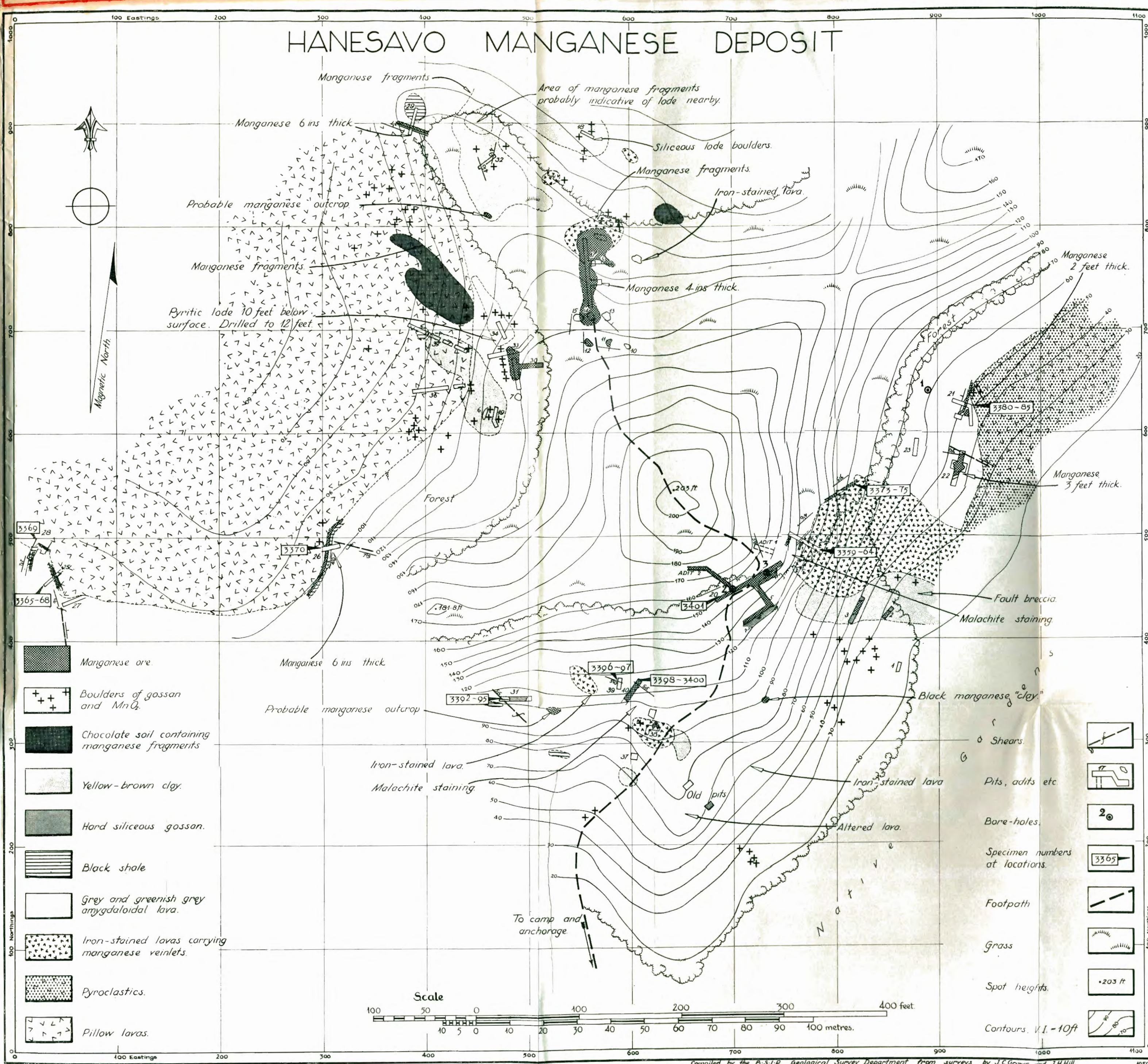


FIG. 35.—Geological Map of Hanesavo Manganese Deposit.

Compiled by the B.S.I.P. Geological Survey Department from surveys by J.C. Grover and J.H. Hill.

REPORT No. 19

DISCOVERY OF A SULPHIDE BODY ON HANESAVO, 1958

By P. A. PUDSEY-DAWSON (March 1958)

In mid-March I relieved Mr. Hill, who had spent several weeks carrying out a general survey and extensive excavations. He had concluded that there were two lavas on Hanesavo. The older was ferruginous, lateritic in colour, with scattered manganiferous veinlets. The more recent lava was notably chloritic, blue-green, and originally blanketed the island. The older red lava does not seem to have been subjected to any deep lateritization prior to the deposition of the younger green lava.

The manganese dioxide is concentrated by secondary processes, irregularly at the surface of the old eroded red lavas—the original manganese minerals being of hydrothermal origin.

In several places there is a thin poorly-developed gossanous layer beneath the manganese. In Pit 35 a zone above the manganese was ferruginous. In some pits the lower pillow lavas were deeply weathered by present-day conditions. It seemed that the ferruginous staining associated with the manganese was due directly to the oxidation of hydrothermally-introduced solutions, and it was therefore concluded that if the more reddish-yellow old lavas were traced downward they might well lead to an ore body or some other source of hydrothermal enrichment. Although this might have meant digging down for a considerable distance with little chance of finding anything, it at least would show the depth of the ferruginous zone—which had not been bottomed by any of the previous excavations.

The soil in Pit 34 was exceptionally yellow and much altered, showing little resemblance to its usual run of present-day lava; being close to a manganese outcrop, I decided to sink a shaft there. After a day's work we passed through a soft yellow clay before the material changed in nature, becoming dry and friable: yet further down it changed to a bright orange colour, and later we passed through a 6-in. band of very leached bright yellow and white material: then immediately into soft uncompacted sugary pyrite. Thereafter we spent four days enlarging and rough-timbering the shaft so that we could dig deeper, and eventually reached a depth of about 28 ft.—in pyrite for the last 15 ft. The deposit was not bottomed. We attempted to drive a shaft to the north, but the dry friable material continued to cave in, making further excavation dangerous, so the workings were abandoned. They subsequently collapsed.

The body was almost entirely of pyrite, except for scattered stringers of white quartz, and lumps of blue

siliceous fragments. Though mostly uncompacted and sugary, here and there were bands and irregular masses of hard massive ore with well-formed pyrite crystals. Irregularly scattered throughout the body were small quantities of blue powdery mineral.

To find whether the body was flat lying, pipe-like, or irregular in shape, a number of pits were sunk around Pit 34, and several diamond drill holes bored.

A pit (43) was dug to 16 ft. about 10 yards to the north, but after passing through a 5-ft. band of red ferruginous lavas reached unaltered purple pillow lavas which appeared to be the local bedrock, and the pit was discontinued. Staining appeared to be due to an offshoot from the main body, and we did not expect to find pyrite below the lavas at this place.

A drill hole was put down to 25 ft. halfway between the new pit and Pit 34; again pyrite was found at about 18 ft. The local rock was soft and friable. The clay-like topsoil kept causing the drill to jam. No cores of samples could be taken of the lower levels as the material was either washed out or fell out while the drill was being lifted. We had the same trouble in the bore hole in Pit 33, and, although no core of pyrite was recovered, at about 15 ft. the drill went down very quickly and easily, just as one would expect in the soft dry sugary and uncompacted material.

Three days were spent drilling holes round the known pyrite in Pit 34. It was apparent that the body was at least 70 ft. to 100 ft. long, and 20 ft. to 30 ft. wide, in accordance with the plan.

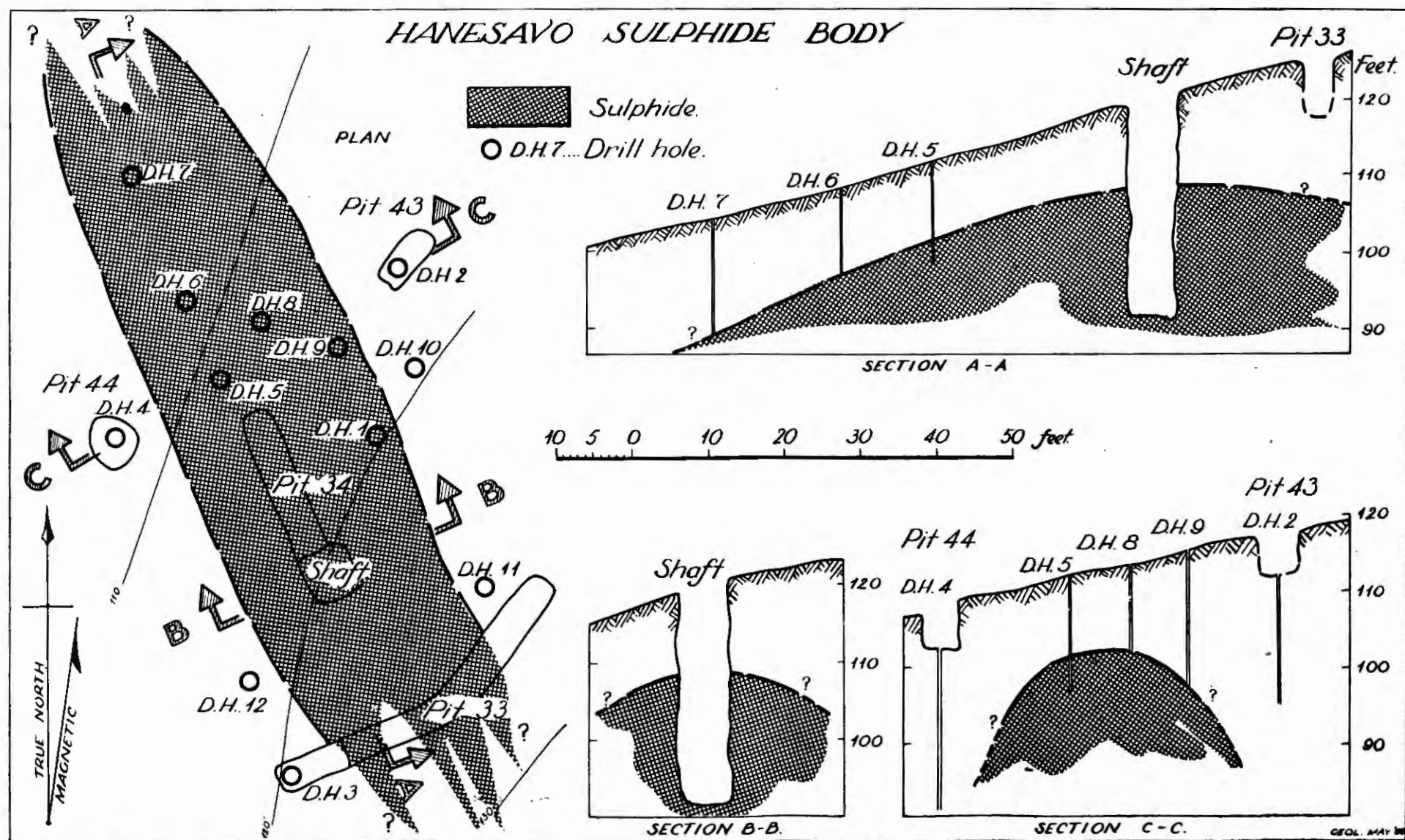
A bulk sample of the sulphide showed that it was made up of about 90% pyrite and the remainder of quartz, feldspar and volcanic glass gangue. Assays showed:

Silver 13.6 dwt. per long ton.

Gold 0.4 dwt. per long ton.

The pyrite crystals are well developed, up to 0.5 mm. in size, and there are also large irregular masses formed of microscopic well-developed crystals. The finely-divided blue mineral is covellite (cupric sulphide CuS) which occurs in minor quantity often enclosed in quartz gangue. Quartz grain size varies from 0.01 mm. to 0.15 mm. and shows a markedly mosaic texture.

The rock is porous in appearance, vesicles occupying 15% to 20% of the total volume, and ranging in individual sizes from 0.05 mm. to 1.0 cm., both round and irregular in shape. Covellite filled some of the cavities, but no trace of hydrated iron oxides was seen, nor was there any evidence of breakdown of the pyrite, which was



perfectly fresh : therefore the forming of covellite from the leaching of chalcopyrite is most unlikely and the covellite seems to be actually a primary mineral. Its finely crystalline nature has the appearance of an encrustation resultant on a sublimation process.

A sieving test of the material gave the following result :

31.3% held on 20 BS sieve ;

56.5% held on 30 BS sieve ;

12.2% passed.

The coarser fraction appeared to contain less sulphide than the others, and more quartz and siliceous material.

One sample was very slightly radioactive (0.002% equivalent ThO_2).

Occasional crystals of a blue-green water-soluble mineral were observed. Biaxially positive, the mineral is probably a member of the melanterite group formed after pyrite*.

* Examinations of various samples and specimens were made at different times by the Mineral Resources Division of the Directorate (Ref. M6278/37 of November 12th) and the Bureau of Mineral Resources, Canberra (Ref. 198F/3 of May 15th).

REPORT No. 20
THE MANGANESE DEPOSITS OF HANESAVO ISLAND, 1958

By C. V. G. PHIPPS
(Department of Geology and Geophysics, University of Sydney)

Nature of the Deposit

The main deposits occur on both sides of a steep grassy ridge and appear to be formed on an old erosion surface. Both the top and bottom of the ore are irregular. Lenses of weathered lava occur within the main body of manganese. These could readily be removed during mining, so would not affect the grade of the product.

The rock above the manganese is generally buff-coloured weathered lava. The maximum thickness of this overburden is 63 ft. Due to the weathered nature of the overburden no difficulty would be encountered in removing this material with a bulldozer.

The width of the main deposit, where exposed, varies from 75 ft. on the eastern side of the hill to 25 ft. minimum on the west side. The maximum thickness exposed by trenching was 18 ft. over a width of approximately 30 ft. on the eastern side of the ridge. This thickness lenses out rapidly to 3 ft. within the next 25 ft. on the north side, and is cut off by a shear on the south side of the exposure. The top of the manganese was followed 60 ft. into the hill by an adit driven by the B.S.I.P. geologists. This had caved in by the time of the writer's visit. It is assumed that the ore exposed on the east and west sides of the hill, between 120 ft. and 140 ft. above sea level, is the same mass of manganese ore. The probable limits of mineable ore are indicated in Fig. 38.

Besides this main orebody another lens of manganese ore occurs 50 ft. to the west on the northern side of the hill. The southerly extension of this deposit may be represented by thin lenses of manganese in excavations

Nos. 39 and 40. It is possible that this deposit is a westerly extension of the main deposit. Overburden limited the amount of trenching possible on this deposit.

Lower down the east hill from the main deposit, several small lenses of manganese occur. Some of this material is very high grade, and although the tonnage potential at present appears small, because of their grade (56.34% Mn or 89.16% MnO₂ for Excavation No. 22) they are considered worth while mining. More of these lenses may be located as mining progresses.

The manganese ore itself is soft and easily removed with a pick and shovel. Hard boulders of silicified (?) material occasionally occur. These were found to be relatively low grade: it would probably prove advisable to discard the more siliceous of these during mining. The bottom 1-3 ft. is often much harder than the ore above. This is probably due partially to a higher percentage of Psilomelane, as the grade of this material was found to be from 50% to 56% Mn. An increase in grade from top to bottom was found to be the general rule. The top foot, often a clayey material, should be removed with the overburden, as the grade was found to be generally below 40% Mn. This material is dark chocolate in colour and readily recognisable.

Tonnage

The ore reserve estimated for the deposit is 10,000 tons. This takes into account only the exposed portions of the smaller deposit outcropping west of the main body. It is possible that another 1,500 tons exist as an extension into the hill of this deposit.

TABLE I

Sample No.	Excavation No.	% Mn	% MnO ₂	Sample length in feet	Remarks
1	5A	35.15	55.62	3.0	Poor grade, dark chocolate material
2	5A	44.01	69.64	3.5	Mostly black with some brown ore and weathered lava
4	5D	50.36	79.70	4.75	Black fine ore
5	5D	46.93	74.26	2.0	Soft ore on top of chocolate lava base
7	5E	48.65	76.99	1.5	Hard ore bottom 18 in. of deposit
8	5F	37.09	58.69	5.5	Hard and soft ore at top of the deposit
10	5F	36.01	56.98	2.0	Silicified hard ore
12	5C	39.41	62.37	1.0	Top foot earthy ore from soil
13	5C	53.47	84.62	1.5	Sample from auger hole
14	5C	55.78	88.27	6.0	Six ft. sample below Sample 12
16	5B	44.15	69.87	7.0	Mixture of hard and earthy ore from side of trench
19	5C	47.14	74.60	5.5	Below No. 16—separated by 1-ft. lava band
22	5C	50.14	79.35	3.0	Bottom 3 ft. of 5C
25	14	44.94	71.12	7.25	Complete section through deposit
28	14	44.03	69.68	6.25	Complete section through deposit—opposite side of pit
29	15	42.41	67.11	3.5	Section through ore
30	14	31.06	49.15	2.0	Top section of Sample 25
31	14	56.13	88.83	1.75	Mid-section of Sample 25
32	15	44.01	69.64	2.75	Bottom section of Sample 25
33	3	50.80	80.39	3.0	Soft black ore
34	33	51.97	82.25	4.25	Harder black clayey
35	30C	47.40	75.01	3.0	Hard black ore—less clay than No. 34
37	17	32.15	50.88	5.0	Manganiferous clay and soil
41	33	53.82	85.17	3.5	Section of top 3 ft. 6 in., 2 ft. 6 in. of good ore
44	22	56.34	89.16	3.0	Section through lens
47	33	54.46	86.18	2.0	Hard ore near edge of the deposit
48	33A	44.66	70.99	3.25	Bottom 3.25 ft.—top foot clayey.

Possibilities of Increased Tonnage

The average thickness used in calculation of tonnage was 5 ft. Should the 18-ft. thickness exposed on the south side of the hill persist any great distance into the hill, 2,500 tons per 50 ft. can be expected.

Small tonnages which would be obtained from small lenses below the main body may become significant should more of these lenses be found.

Sampling and Grade of the Ore

All trenches containing mineable ore were sampled from vertical channels. Where old trenches were sampled, 6 in. of the surface was removed to eliminate any effect from weathering.

Of the 48 samples collected from the deposit, 27 were initially selected to give an average grade of ore. The results of the assays of these samples are given in Table I.

Taking all the samples assayed into account, the average grade of the deposit is estimated as 45.80% manganese metal. Assuming 50% of the low grade ore (less than 40% Mn) can be eliminated from the final product during mining, the final grade of ore product is estimated as 47% Mn metal.

It was noted in the field and later brought out by assays that there is an increase in grade from top to bottom of the deposit. Five of the samples assaying less than 40% Mn were from the top of the deposit or

obviously low-grade areas. This low-grade material could be discarded during mining.

It must be emphasised that the average grade given above assumes that lenses of lava occurring within the deposit are removed during mining by hand picking. Mechanical bulk mining would produce a lower grade product, as these lavas would be included. For this reason mechanised mining is not recommended.

Harbour Facilities

The entrance to the passage between Hanesavo and Buena Vista Islands affords an excellent harbour. Little difficulty would be encountered in building facilities for tying ships alongside the reef within a quarter of a mile of the deposit of manganese (Fig. 37). The depth of the water exceeds 40 ft. within 30 ft. of the edge of the reef.

TABLE II
ANALYSES OF SELECTED SAMPLES OF TYPICAL ORE

	Sample No.				
	14	22	25	28	34
Loss on drying at 100°C. ..	1.64%	0.64%	1.76%	2.37%	1.65%
Silica (SiO ₂) ..	0.97%	14.59%	2.70%	1.80%	2.67%
MnO ₂ ..	88.27%	79.35%	17.12%	69.68%	82.25%
Fe ₂ O ₃ ..	2.40%	1.66%	15.28%	16.97%	3.58%
Al ₂ O ₃ ..	0.38%	0.08%	2.15%	0.92%	1.14%
Phosphorus as P. ..	0.020%	0.015%	0.045%	0.050%	0.033%
Sulphur as S. ..	0.074%	0.095%	0.112%	0.113%	0.112%

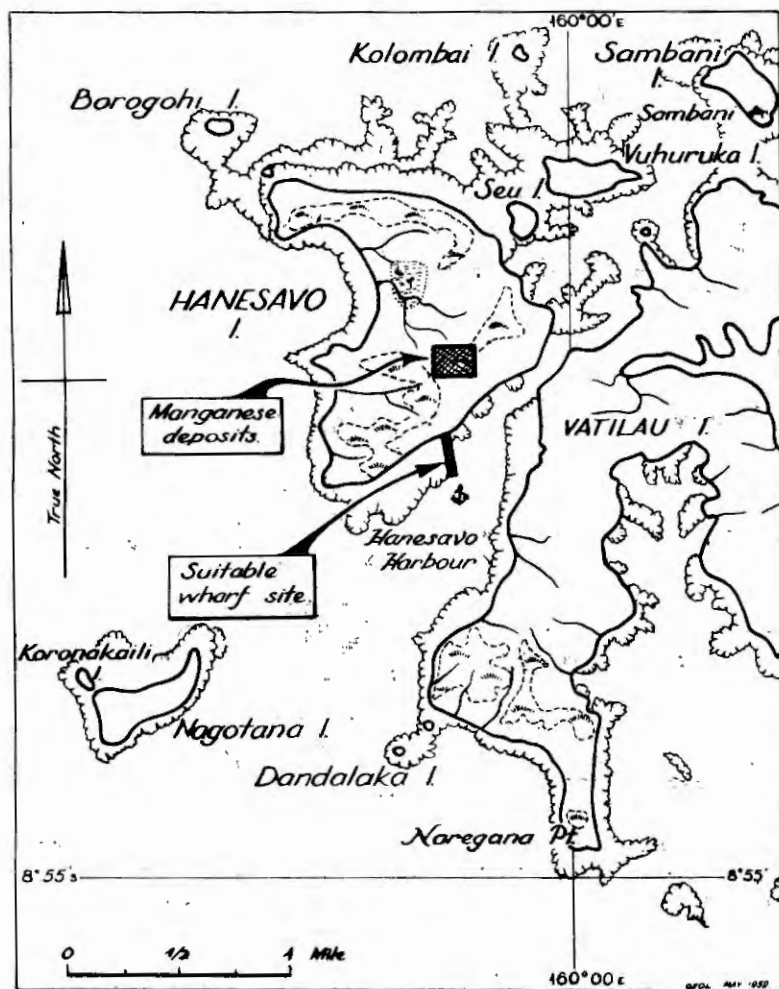


FIG. 37.

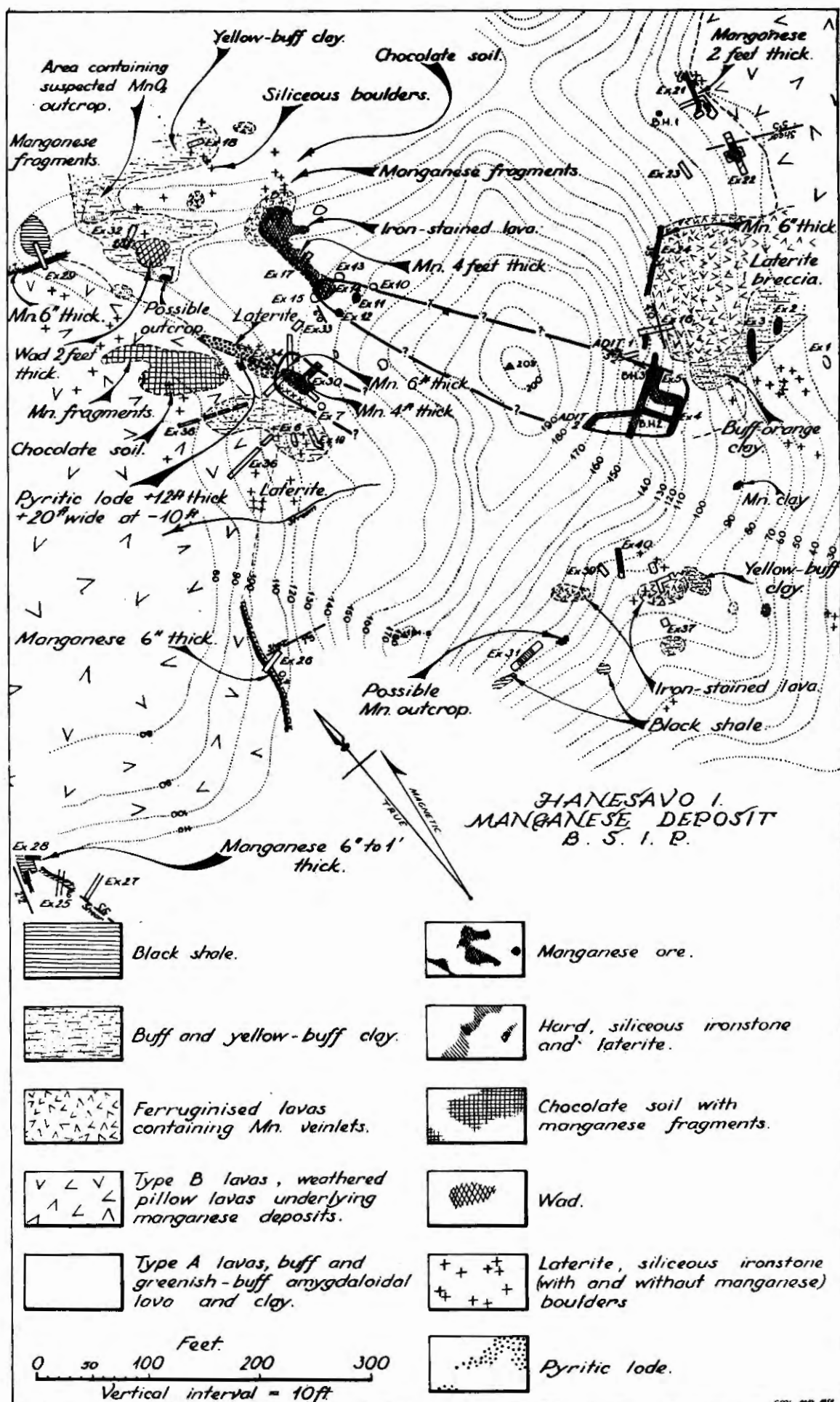


FIG. 38.

FURTHER EXPLORATION OF THE BETILONGA AREA OF GUADALCANAL, 1957

By J. H. HILL

Part I.—The Geology of the Betilonga Area between the Betikama River and the Kavo Range

Introduction

The area is roughly eight by six miles, its boundaries marked by the Betikama River to the north, the Betisahata to the west, the Vuralosa to the east, and the crest of the Kavo Range to the south. This first detailed survey was done during the latter half of 1958.

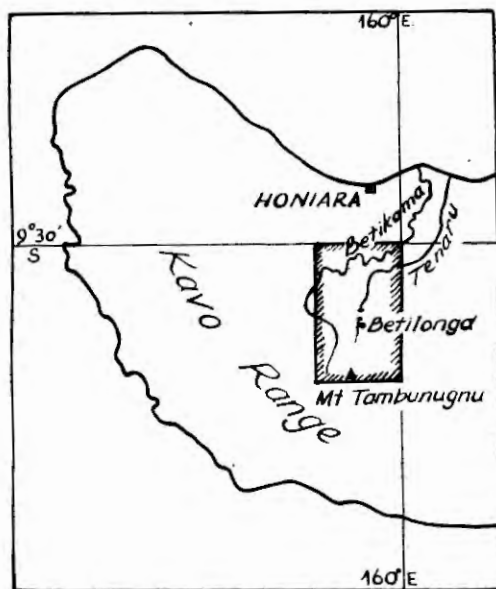


FIG. 39.—Sketch showing location of area.

The Betilonga Basin was briefly prospected for gold in the 1930s, and was examined by Mr. Grover during two weeks in 1952 (see Memoir No. 1). Dr. Coleman, of the University of Sydney, made reconnaissance traverses and photogeological interpretation of the country north of the Nunukama River during 1956. In 1957 Mr. Pudsey-Dawson gained further data in a traverse east of the Tasi and Lambutouna rivers. The geological map is based on Dr. Coleman's broad interpretation: here amended in some details.

Physiography and Geomorphology

The area, still in the youthful stage of dissection, is drained by three river systems, the largest being the Betikama and its tributary, the Betisahata, draining the northern and western region; the south-east and south is drained by the headwaters of the Nunukama-Nalimbu River. The Betilonga River drains the central region, and will be dealt with more fully in Part II of this report.

Except for the Betilonga Basin the land is deeply dissected by strongly insequent tributaries branching from the original consequent drainage channels. All river valleys, except the Betikama, are V-shaped and tortuous.

The valleys at the foot of the Kavo Range are of the order of 1,600 ft. deep, but within two miles of the crest (at about 5,000 ft.) they increase in a spectacular fashion, with slopes between 2,500 ft. to 3,000 ft. high on both sides. A number of well-defined knick points have interrupted the steep profile of many of the major tributaries and indicate that there are at least two erosion cycles

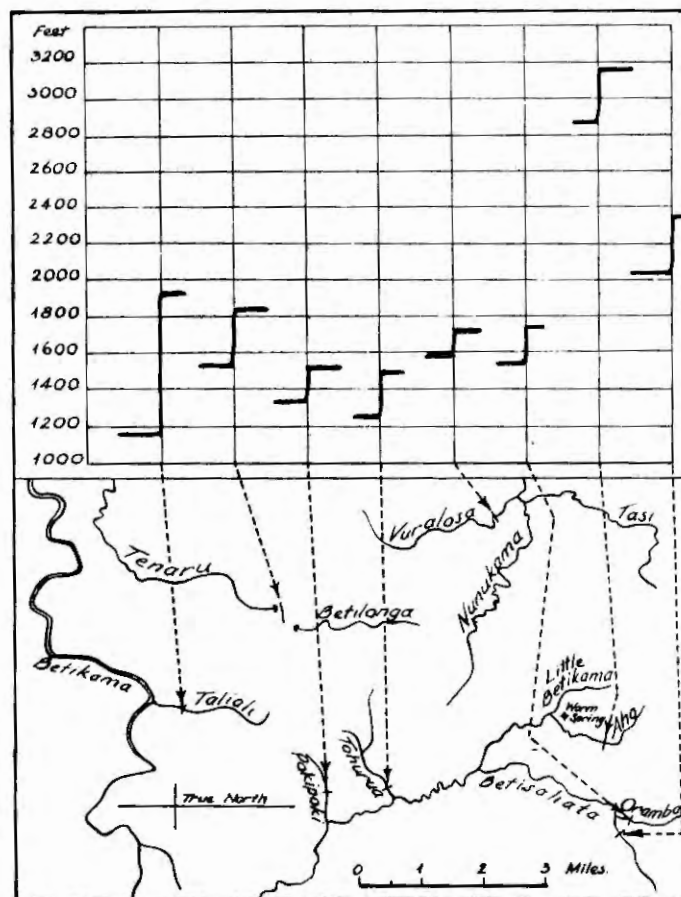


FIG. 40.—Diagram illustrating the vertical heights and relative altitudes of waterfalls at "knick points".

actively reducing Guadalcanal. It will be seen that the knick points (with two exceptions) are usually between 200 ft. and 300 ft. high, while the bases of the falls lie between 1,100 ft. to 1,600 ft.

In the Betikama valley, where lateral corrasion is developing, meanders are already incised to a depth of 1,200 ft. below the surrounding country. It is interesting to note that lateral corrasion has also produced incised meanders along the Betisahata and Nunukama rivers where they flow across stocks of diorite, intrusive into the basement agglomerates.

A warm spring issues from a fissure on or just north of the easterly-trending fault, cutting the Tanamasa and Betikama rivers just north of their junctions with the Aho (see Fig. 40).

Structure

Slight folding was apparently followed by extensive faulting and uplift to at least 5,000 ft. Uplifted blocks of country have exposed the "basement" agglomerates around the Betilonga Basin, and the sedimentary rocks which were faulted down into the basement have been preserved from erosion. To the north-east and north-west the limestone, calcarenites and marls are still blanketed by the Toni Tuffs.

The largest block-faulted area, of about 10 square miles, lies between the Chipakalau, the Nunukama, the Betisahata and the Vuralosa rivers, and a small rift valley extends from east to west along the centre of this faulted block, about 300 yards wide and $1\frac{1}{2}$ miles long; Olsen Creek flows over the down-faulted Tangaraisu Marls for most of this distance.

A smaller horst block between the Betikama and Chipakalau Rivers has been uplifted approximately 650 ft.; its eastern and western boundaries extend north-south a mile distant on either side of the Taliali River.

These latter rocks have also been extensively sheared, with maximum disturbance in the Chipakalau and Olsen Creek valleys and along the headwaters of the Betilonga.

The regional strike of the sediments varies between south and south-east, while dips vary between 40° and 70° west. Shear lines, faulting and lineations exhibit similar strike directions, especially in the sedimentary formations to the south-west.

The three formations overlying the Basement Complex were laid down in a subsiding syncline, the limbs of which appeared to dip at about 30° towards each other.

The Betilonga Limestone increases in thickness from south to north, and the Tina Calcarenite shows a corresponding decrease. Their distribution suggests that the source of the material was derived from a landmass to the south. The Tangaraisu Marl thickness is not precisely known because of erosion: it is at least 500 ft. thick.

At the northern end of the syncline the Basement Complex has been faulted against Mt. Austen Beds indicating a vertical movement of at least 3,000 ft. At the southern end the sediments have been up-faulted and subsequently removed by erosion exposing the Basement rocks.

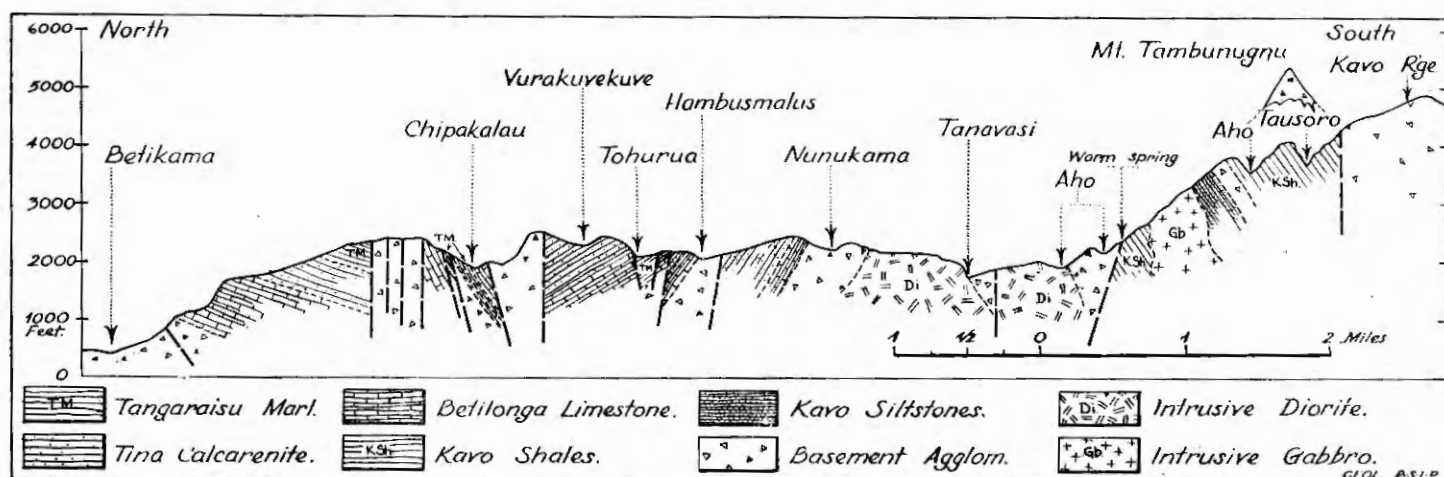


FIG. 41.—Geological section.

Many river courses have been influenced by the regional faulting, the Chipakalau being one of the best examples. The Betisahata and its tributary, the Aho, have followed two major shears, while the Nunukama is confined by two parallel shears 400 to 500 yards apart. Basement rocks, predominantly agglomeratic, have been extensively sheared to a soft blue-grey pyritic gouge, with occasional talc-filled fractures in the shattered rocks adjacent thereto. The talc is widely scattered, and does not extend laterally for more than a few feet anywhere (spec. 3515, 3517, 3521, 3608).

Quartz lodestuff veins are also closely associated with the shearing in the agglomerates and the faulted contacts between the agglomerates and the Tangaraisu Marls.

Generally speaking, the syncline has been broken by vertical or steeply-dipping normal faults with throws varying between 1,000 ft. and 3,000 ft. The intense shearing around the Betilonga Basin is apparently due to two reversed faults dipping 60° southward and having a vertical displacement of about 2,000 ft. Together with the effects of normal faulting these faults have displaced the sediments horizontally by half a mile to the northward.

Faulting at the northern end of the syncline is post mid-Pliocene, since Mt. Austen Beds have been thrown against the Basement. In the central and southern parts the faulting is later than mid-Miocene and is perhaps post upper-Miocene.

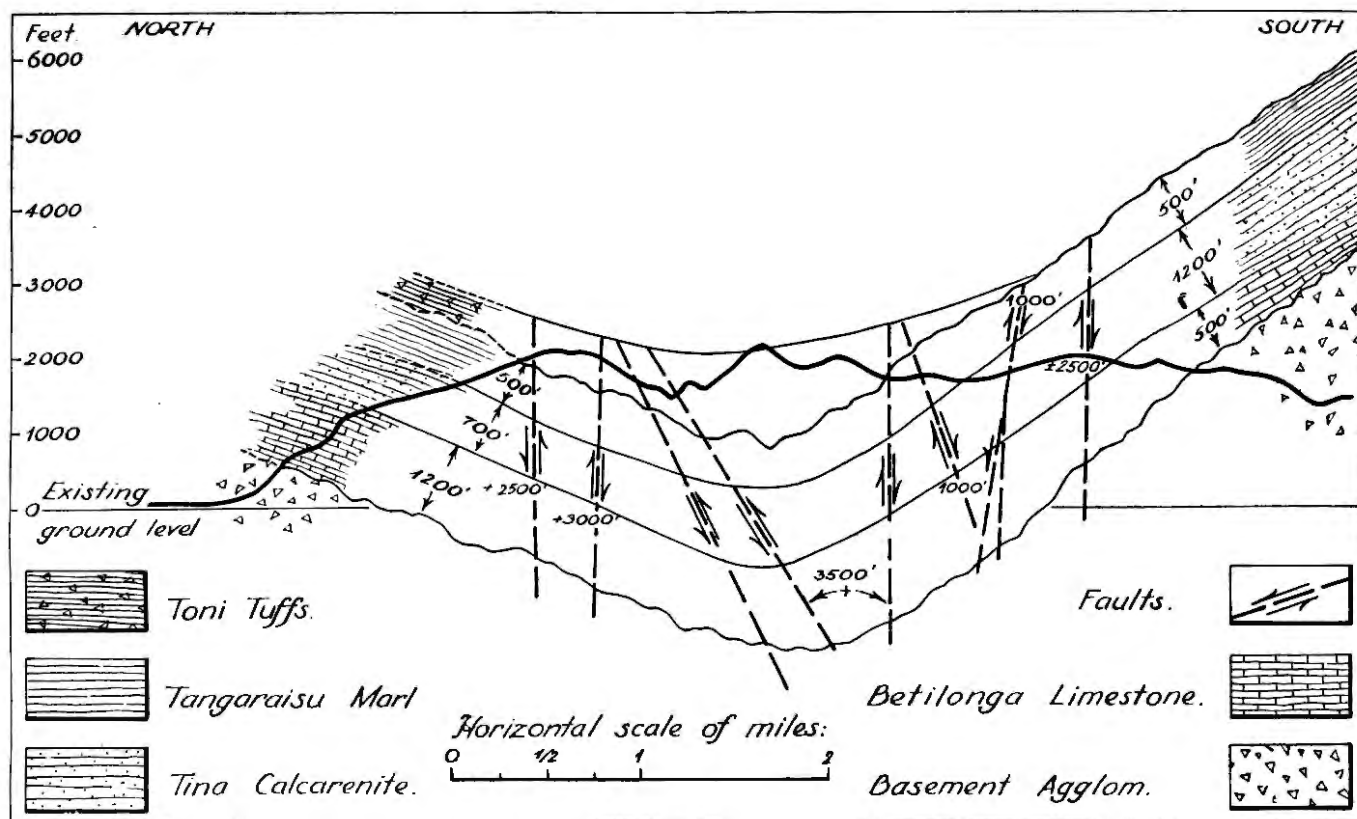


FIG. 41A.—The structure of the Betilonga syncline showing location of fault planes and their approximate relative movements.

General Geology

The geological succession appears to be :—

- | | |
|--------------------------------------|--------------------------------|
| 8. Mt. Austen Beds | Mid-Pliocene. |
| 7. Berande Beds | Upper-Miocene,
Mid-Miocene. |
| 6. Toni Tuffs | Mid Upper-Miocene. |
| 5. Tangaraisu Marl ± 200 ft. | Mid-Miocene. |
| 4. Tina Calcarenite $\pm 3,000$ ft. | Mid-Miocene. |
| 3. Betilonga Limestone ± 600 ft. | Lower Mid-Miocene. |
| 2. Kavos Shales $\pm 3,000$ ft. | Pre-Miocene? |
| 1. Basement Complex | Pre-Miocene. |

1. The Basement Complex

The Basement Complex comprising the consolidated and soft fragmental agglomerates, intrusive diorites, and isolated stocks of coarse-grained gabbros constitute most of the outcrops south of the Nunukama and west of the Betisahata rivers. Basement rocks are also exposed along the floor of the Betikama valley north of the Betilonga Basin.

The agglomerates show considerable variation, but are usually dense dark grey rocks (spec. 3609) which weather to a hard surface with rounded humps. The solid fragments of ejected material vary between $\frac{1}{2}$ in. and 9 in. across, but 18-in. "bombs" are not uncommon. The fragments are usually firmly embedded in the finer-grained tuffaceous matrix. Under the microscope the rock is seen to be composed of twinned andesine-

labradorite fragments lying in a fine-grained groundmass of plagioclase microlites. Many of the fragments are distinctly zoned and some of the larger laths are built up of two generations of plagioclase. Pale green anhedral to subhedral pyroxenes are also scattered through the groundmass, together with anhedral grains of pyrite.

There appears to be no difference in size between the agglomerate fragments in the Betikama Valley and those at the foot of the Kavos Range. Soft iron-stained fragments are found within the agglomerates on the northern slopes of the Kavos Range (spec. 3607), but this characteristic was not observed north of the Nunukama River. The groundmass is composed of fractured laths of twinned andesine-labradorite set in fine weathered chlorite. A few hundred yards south of the fault cutting across the Vuralosa River the agglomerates pass into an unusual occurrence of pale medium-grained tuff (spec. 3593), composed mainly of weathered feldspars: this rock was not observed elsewhere.

The agglomerates in the valleys along the northern flanks of the Kavos Range (spec. 3594, 3591, 3596, 3614) have been invaded by stocks of diorite, with the formation of hybrids (spec. 3595, 3599) adjoining the contacts. The intrusions have so influenced the course of the Nunukama and Betisahata rivers that incised meanders have formed along otherwise straight V-shaped valleys.

The coarse-grained diorites have a hypidiomorphic-granular texture: an interlocking aggregate of anhedral and subhedral oligoclase-andesine laths and pleochroic

hornblende. Many of the plagioclase crystals are zoned. Magnetite is present as subhedral to anhedral crystals.

Pyrite mineralisation in the agglomerates was only observed in three places outside the Betilonga Basin. Fine disseminations are scattered through the basement rocks along the Betisahata between the Hambusmalus and the Pokipoki rivers. A 40-ft. wide vein of siliceous pyritic lodestuff crops out at the junction of the Betisahata and Hambusmalus, striking 160° and dipping 55° westward. The core of the vein consists of sheared pyritic quartz (spec. 3615) grading outward into the unaltered pyroclastics. (For a full description see Part II of this report.)

A few hundred yards south of the Betikama-Taliali junction the basement agglomerates have been strongly sheared and pyritised (spec. 3529) along vertical planes striking 360°: the pyrite being found as disseminations and crystalline masses with individual crystals up to 2 mm. diameter.

A minor intrusion of dark, coarse-grained, greenish-grey gabbro (spec. 3602) containing feldspar phenocrysts up to 3 mm. long has invaded the black Kavo Shales in the headwaters of the Aho River. Lineations in this body strike 70° and dip 65° north. The igneous contact is obscured by talus but hybrid rocks are exposed along the river bank, fresh and consisting of anhedral and subhedral laths of labradorite-bytownite and grains of pyroxene. Many of the plagioclase laths consist of two generations. The older crystals have rounded terminations and poikilitically enclose pyroxene fragments and gas bubbles. The younger generation encloses the older and the two generations are in optical discontinuity with each other.

Around the Betilonga Basin the agglomerates have been intensely sheared and in many places have been crushed to a blue-grey pyritic gouge.

2. The Kavo Shales

Faulted into the "basement" on the northern slopes of the Kavo Range are dark shales (spec. 3601) a few thousand feet thick, massive in appearance. No reference has been made to these shales in previous reports and they will be referred to as the Kavo Shales. They have a dark, fine-grained groundmass containing minute angular fragments of pyroxene, twinned plagioclase and scattered microfossils*. Bands of a pale greenish-grey spotted rock (spec. 3603) occur as isolated lenses within the Kavo Shales, and consist of fine-grained siltstone containing dark grey cherty concretions 1 mm. to 5 mm. in diameter.

For the last mile upstream the course of the Aho River has been controlled by the north-west strike of the Kavo Shales (spec. 3605, 3606). Between 4,800 ft. and 5,000 ft. altitude the sediments cut out against a north-easterly fault and from here to the peak of Tambunugnu (3,500 ft.) the country rock is a dark andesitic agglomerate containing iron-stained fragments about $\frac{1}{8}$ in. across.

The black shales in the Betisahata Valley (spec. 3610,

3612, 3613) are similar to those in the Aho valley, but with slightly smaller cherty concretions in the spotted siltstone. In the Betisahata Valley one band of siltstone was found, striking 160° and dipping 30° east. The rounded cherty concentrations are more numerous here and smaller than in the Aho Valley, varying in size between $\frac{1}{16}$ in. and $\frac{1}{8}$ in. (spec. 3611). In the Aho valley the regional dip of the Kavo Shales is 70° south-west, but two miles westward in the Betisahata valley the beds dip 20° to 30° north-east.

3. The Betilonga Limestone

The Betilonga Limestone which overlies the basement agglomerates is only found north of the Nunukama River except for one small occurrence in the foothills of the Kavo Range. It is a remarkably homogeneous formation, free from argillaceous or arenaceous material. It has developed most a mile south of the Betikama River and is exposed in the precipitous gorges and waterfalls of the Taliali River. A prominent limestone scarp 650 ft. high forms the southern wall of the Betikama Valley for a distance of two miles: hard and crystalline (spec. 3566, 3573, 3616), occasionally ironstained.

Limestone 200 ft. thick crops out in the Kansahe Valley down-faulted into the basement country a mile south of Mangapau village; it can be followed to the Betisahata-Pokipoki junction for four miles to the northwards and appears to be faulted. The limestone thins to 100 ft. in the Pokipoki valley: the contact with the Basement Complex dips gently northward from an altitude of 2,400 ft. in the Kansahe valley to 860 ft. in the Pokipoki valley. East of the Kansahe the limestone has been displaced a quarter of a mile to the north-west by a fault.

The only occurrence of limestone south of the Nunukama was found in the Betisahata valley between the Orambau and Sarema Rivers. For about 300 yards the valley floor was littered with numerous blocks of limestone up to 20 ft. diameter which appeared to have fallen from the southern side of the valley. The limestone-basement contact was not observed.

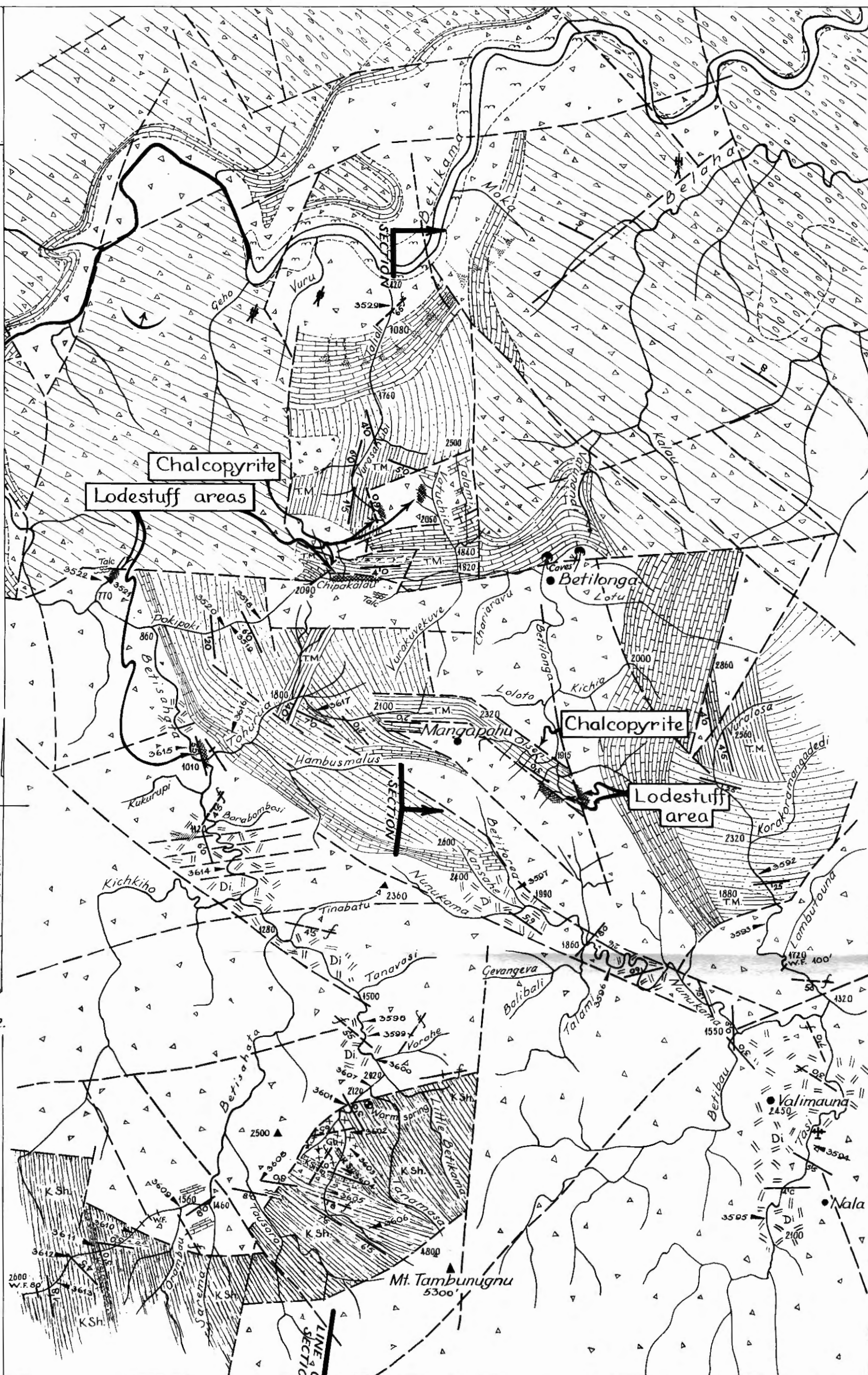
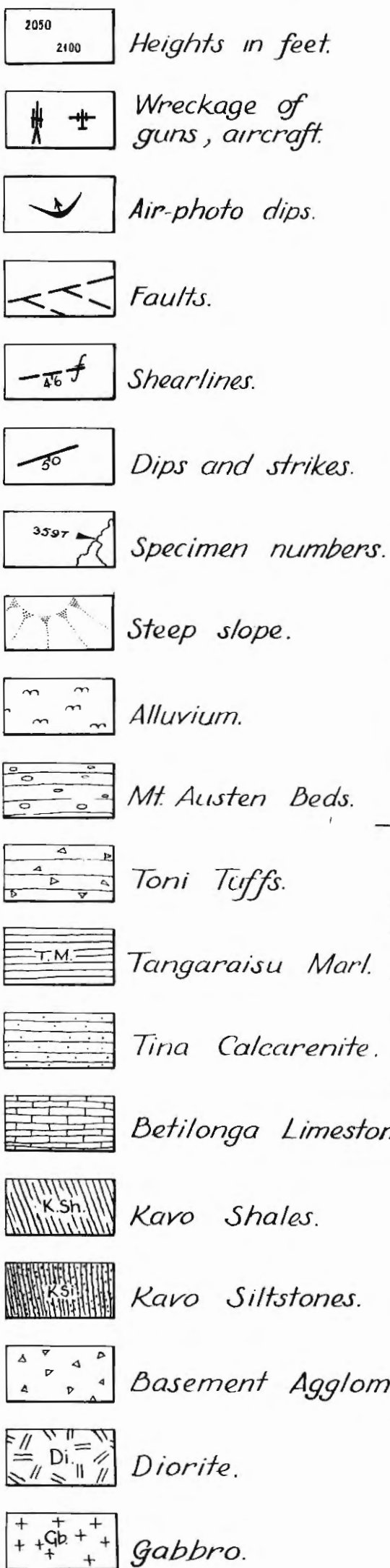
4. The Tina Calcarene Formation

This formation attained its greatest development in the valleys of the Taliali, Pokipoki, Tohuria and Vuralosa. All the rocks comprising it are calcareous and include such diverse types as coarse conglomerates, quartzite pebble beds, quartzites and soft current-bedded siltstones. These sediments indicate turbulent conditions of deposition between the periods of quiescence when the Betilonga Limestone and the overlying Tangaraisu Marls were deposited. The regional strike of the Calcarene beds varies between 340° and 20°, with a dip of 20° to 60° westward. The predominant rock type is a hard, off-white to pale grey calcareous quartzite and small-sized conglomerates (spec. 3520, 3560, 3564, 3592, 3617) containing pebbles of limestone, grey quartzite and dark and fine-grained andesites. They are sub-angular to sub-rounded, and vary between $\frac{1}{4}$ in. to $\frac{1}{2}$ in. diameter. Microfossils are scattered throughout these rocks.

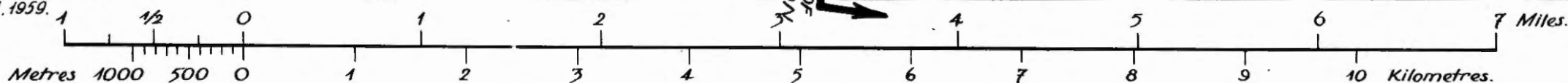
* Specimens have been sent to Dr. P. J. Coleman.

GEOLOGICAL
SKETCH MAP
of the
BETILONGA AREA
GUADALCANAL

KEY TO SYMBOLS



Geological Survey Department.
Honiara, B.S.I.P.
April, 1959.



5. The Tangaraisu Marls

There is a gradual transition from the Tina Calcarenite to the overlying Tangaraisu Marls, which are well-bedded yellow-brown mudstones and siltstones (spec. 3532, 3567). The sequence is occasionally interrupted by bands of sandstone, calcareous conglomerate, and more rarely, limestone, up to 5 ft. thick. Because of the heavy faulting around the Betilonga Basin the mudstones and siltstones are highly sheared, particularly in the Olsen Creek and along the Chipakalau Valley (full details in Part II). The bedding directions have been influenced by faulting. In the Olsen Creek area the beds dip 20° north, in the Chipakalau Valley they dip 40° south, and along the Vuralosa and Vurasahubi valleys the beds dip 45° and 15° westward respectively.

6. The Toni Tuffs

This formation is exposed north of the Betilonga Basin on either side of the Taliali fault block. Little can be said about these beds as the field work was carried out in areas in which Toni Tuffs had been largely removed by erosion. The tuffs were only found at the western end of the Chipakalau valley, unconformably overlying Tina Calcarenite and a conglomeratic phase of the Betilonga Limestone. The Toni Tuffs are friable, unsheared blue-grey agglomerates free from pyrite; fragments vary between $\frac{1}{4}$ in. and 2 in. across.

Economic Geology

Lying in the basement agglomerates are areas of finely disseminated pyrite which becomes more concentrated

in the vicinity of intense shearing, and it is especially abundant in the Betilonga Basin (for details see Betilonga Report, Part II).

Vein bodies of pyritic siliceous lodestuff are usually found adjacent to these zones of intense shearing, parallel to the major faults. Outcrops have been found at the Betisahata-Hambusmalus junction, in the headwaters of the Vutuchichi and in a minor tributary of the Betishata west of the Chipakalau valley.

Siliceous lodestuff veins are also exposed along faults between the basement and the Tangaraisu Marl in the headwaters of the Vurasahubi Creek, west of the Vutuchichi lode area, along the Chipakalau valley, and in the Betilonga headwaters.

The principal strike directions of the lodestuff is north-south and east-west, sub-parallel to the strike of the main fault lines.

Conclusion

A succession of dark shales hitherto not reported has been found on the northern flanks of the Kavo Range and has tentatively been called the Kavo Shales.

Siliceous mineralised veins of lodestuff, some substantial, were found in the Basement Agglomerates around the Betilonga Basin and appear to be genetically related to bodies of diorite intrusive into the basement. Disseminated pyrite is found in widely scattered localities in the Basement Agglomerates, but is most concentrated in the vicinity of intense shearing. No assays are yet available of the samples taken.

Part II.—The Geology of the Betilonga Basin Area, with special reference to the mineralised areas

1. General

The "basin" area is about three miles from east to west and two miles from north to south, roughly triangular in shape, and the Betilonga River system drains the area through limestone caves at its northern end*.

2. Object and Scope of the Survey

The object of the survey was to attempt to delineate known mineralised areas and locate new ones, if any, by detailed geological mapping, which was begun in July 1958.

By mid-December, when work ceased, a detailed map on a scale of 400 ft. to 1 in. had been made of the Chipakalau, Olsen Creek and Vutuchichi tributaries; considerable progress had been made also with mapping the Vurakuvekuve tributaries and the Betilonga headwaters. Detailed river traverses were also made of the Taliali headwaters and the Pokipoki Valley to the north and west of the Betilonga area.

* On emergence about 500 yards to the north the river is sometimes known as the Belaha, later as the Tenaru. The name Tenaru has been adopted for the river north of the limestone caves.

3. Physiography and Geomorphology

The Betilonga drainage basin lies about nine miles inland from Honiara. The lowest point (1,790 ft.) is at the southern upstream entrance to the caves and the highest (2,800 ft.) at the eastern boundary along the limestone divide between the Kichia and Vuralosa Rivers. The main river valleys are generally less than 2,000 ft. above sea level, and it is only around the headwaters that the individual tributaries fall steeply from the divide, whose height varies between 2,200 ft. and 2,800 ft.

There are two principal rivers, the Betilonga and the Chipakalau; owing to the relatively small catchment area these are not usually subject to dangerous flooding. However, in the narrow subterranean river course exit through the limestone caves, broken tree trunks (up to 20 ft. in length) are wedged into the roof of the tunnel 15 ft. to 20 ft. above the normal stream level, suggesting floods of recent date. Meanders are common along the Betilonga near the village, some incised in the alluvium to a depth of 15 ft. River terraces have been formed at irregular intervals in the lower part of the valley, usually less than 50 ft. wide.

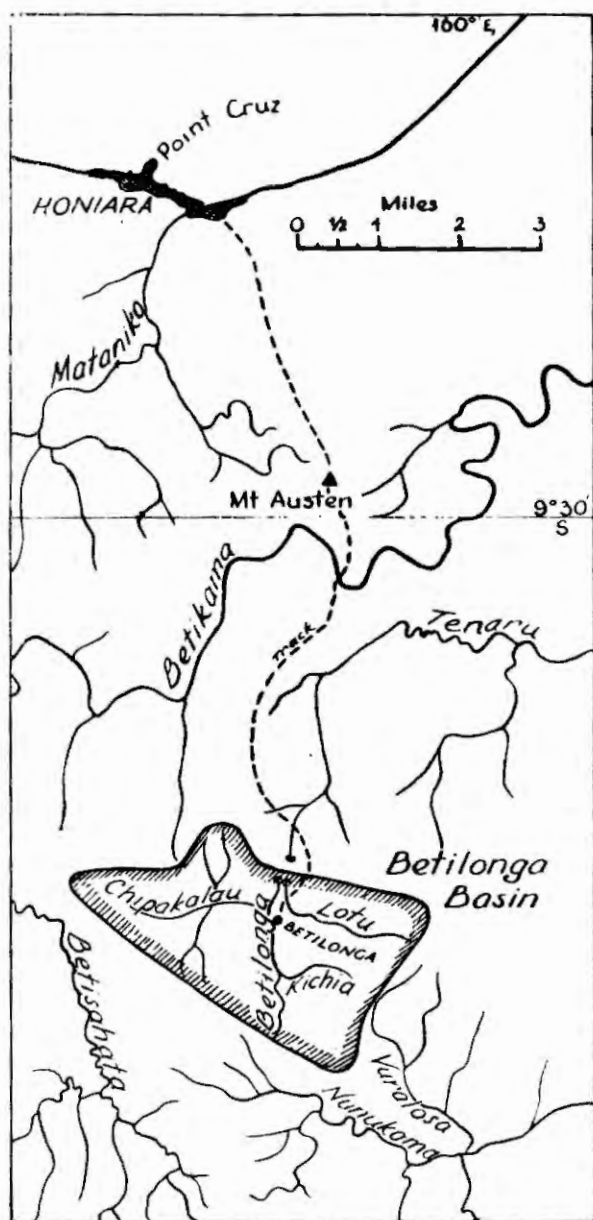


FIG. 43.—Location of the area.

Faulting has influenced the regional drainage pattern, particularly along the Chipakalau Valley. The Chipakalau fault has been traced from the headwaters to within 1,000 ft. of its junction with the Vurakuvekuve and Vatuchichi. Except for a short distance along the eastern and western ends of the valley it lies within 200 ft. of the river bed and has steeply to the south, causing the river course to shift laterally southward in its lower reaches.

The Tangaraisu Marls in the Olsen Creek Valley dip 20° to 40° northward, and this has similarly caused the river to shift laterally in a northerly direction.

4. General Geology

(a) The Basement Complex

On the southern side of the Chipakalau Valley the

Basement rocks contain irregular lenses of ironstained weathered material (spec. 3413). Deep weathering prevails on and near the divides (at an altitude of 2,150 ft.) where the agglomerates have produced a soft brick-red lateritic clay.

Intense shearing of the agglomerates has produced numerous zones of blue-grey gouge containing disseminated pyrite (spec. 3565). Although concentrated notably in the gouge, the pyrite disseminations form an aureole of mineralisation which merges into the surrounding unaltered rocks. Pyrite is particularly widespread in the Vatuchichi and Chipakalau Valleys.

In thin section the agglomerates are seen to consist of a weathered aggregate of plagioclase, pyroxene and occasional laths of pleochroic hornblende. The plagioclase is mainly andesine-labradorite, twinned according to the albite and combined albite-carlsbad laws. Larger crystals of plagioclase, commonly saussuritised, poikilitically enclose grains of hornblende and pyroxene. Other secondary minerals include chlorite and calcite. Octahedral pyrite crystals are scattered through the groundmass.

The principal shear lines in the Basement rocks strike about 360° and 90°.

(b) The Diorite Intrusives

Two diorite intrusions are exposed in the pyritic agglomerates at the western end of the area (spec. 3522) and show coarse-grained white plagioclase and dark green pleochroic hornblende with individual crystals up to 3 mm. in length. Minute crystals of primary pyrite have been observed in a number of exposures.

The plagioclase laths are composed of euhedral to subhedral oligoclase-andesine crystals twinned according to the albite law. The grains are fractured, and curved twin lamella are frequently observed. Strongly pleochroic hornblende occurs as large ragged plates, and euhedral to subhedral crystals. Anhedronal magnetite is scattered through the groundmass, and isolated anhedronal quartz grains exhibiting undulose extinction were observed in a few thin sections.

In the Olsen Creek headwaters a deeply embedded boulder of diorite (spec. 3574) 4 ft. across was found in the agglomerates.

(c) The Betilonga Limestone

This is exposed in the Olsen Creek headwaters, the Chipakalau and Vatuchichi Valleys, and a few hundred feet west of the Betisahata-Pokipoki junction. It is most extensively exposed, however, in the valleys of the Vatuchichi and Talam, where it is considerably more than 200 ft. thick. Owing to the extensive faulting the true thickness cannot be obtained.

The limestone is massive, unbedded, and consists of hard white recrystallised limestone (spec. 3566, 3573) frequently stained by films of hematite. At the western end of the Chipakalau Valley, however, the limestones give way to gritty calcareous small pebbly conglomerates (spec. 3412, 3414) containing sub-angular to sub-rounded pebbles (up to 1 in. across) of off-white limestones and

dark fine-grained andesites containing disseminated pyrite and chalcopyrite. Tuffaceous limestone pebble beds, about 50 ft. thick (spec. 3489), are exposed in the north-western Chipakalau headwaters. The limestone pebbles are up to 2 in. across and show well-developed slickensided surfaces, indicating post-depositional faulting.

(d) *The Tina Calcarenite*

This formation is exposed along the Pokipoki and Vurasahubi Valleys, and consists of a series of calcareous small pebble conglomerates (spec. 3518), calcareous sandstones and softer tuffaceous sandstones (spec. 3519). The sequence is at least a few thousand feet thick. Several hundred feet of the succession consist of hard calcareous sandstones containing scattered limestone pebbles.



PLATE XIV

Sandstones of the Tina Calcarenite Formation in the Vurasahubi Valley, dipping steeply westwards.

(e) *The Tangaraisu Marl*

The siltstones are relatively soft, friable, greenish-grey, and contain isolated rounded pebbles of limestone and andesitic material up to $\frac{1}{2}$ in. across set in a tuffaceous

matrix (spec. 3532). The formation has often been so extensively sheared that the bedding has been obliterated. Conglomerates and dark tuffaceous pebble beds (spec. 3419, 3496, 3526) form well-defined bands in these shattered rocks. Intercalated lenses of limestone and sandstone are found in the Chipakalau and Vurasahubi Valleys, sometimes attaining a thickness of 100 ft.; but more usually they are only a few feet thick.

Dark tuffaceous current-bedded siltstones and sandstones are exposed along the western end of the Chipakalau Valley (spec. 3487, 3490, 3562, 3569). A few yards up the Behoa stream south-east of Olsen Creek-Betilonga junction the mudstones contain lenses of hard indurated blue-grey quartzite a few inches thick and separated by narrow bands of mudstones.

(f) *The Toni Tuffs*

An agglomeratic phase of the Toni Tuffs is exposed at the western end of the Chipakalau Valley; a blue-grey fragmental rock free from crush zones and pyritic disseminations. Megascopically it hardly differs from the Basement Agglomerates which are found further to the east.

5. Structure

(a) *General*

The rocks of the Betilonga Basin have been extensively faulted and the entire area appears to have been the focus of large-scale fracturing. To the north and south, however, there does not seem to have been the same intensity of disturbance.

The extensive faulting throughout the area has badly disrupted the regional dip and strike of the various formations; Coleman (1957) showed the regional dip to be approximately 20° northward. Only in the Olsen Creek sediments was this regional dip observed; the beds dip southerly in the Chipakalau Valley and westwards at the western end of the area.

Although between the Betikama Valley and Kavo Range the picture is one of large-scale block faulting, in the relatively small area of the Betilonga Basin this is not so apparent, although it is obvious that the area has been greatly disturbed.

Structurally the area can be divided into the following regions:—

- (i) The Chipakalau Valley.
- (ii) The Vatuchichi-Talami area.
- (iii) The Pokipoki-Betisahata Valleys.
- (iv) The Olsen Creek and the Betilonga headwaters.

(b) *The Chipakalau Valley*

This is a fault-line valley which extends from east to west for nearly 2 miles: the actual fault zone is not more than a few feet wide, but the rocks exposed on either side of the valley have been heavily sheared.

An irregular fault has been traced for a distance of 3,000 ft. along the northern side of the Chipakalau Valley a few hundred feet north of the Chipakalau fault, and repeated faulting along this side of the valley has exposed a 50-ft. wide band of sheared pyritic basement aggro-

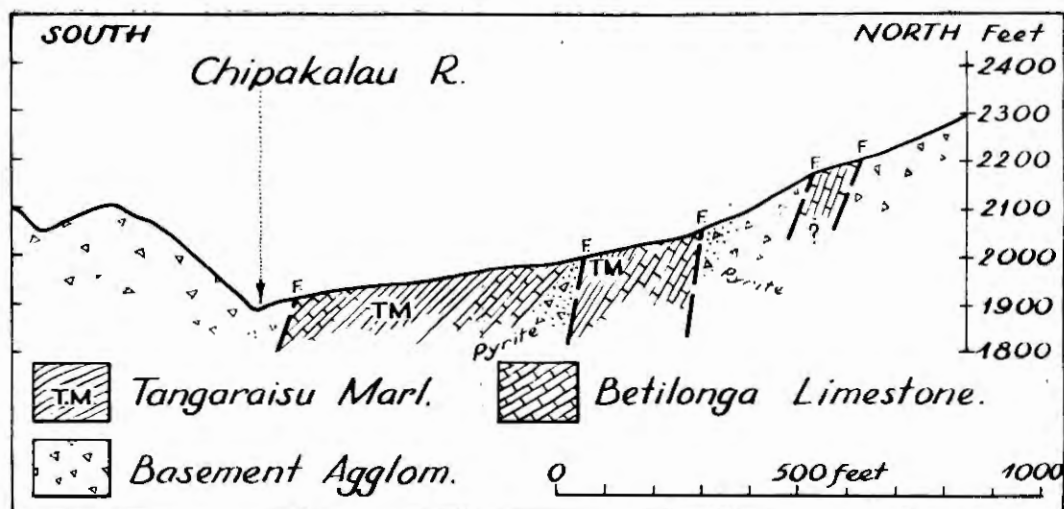


FIG. 44.—Section across the Chipakalau Valley.

merates sandwiched between Betilonga Limestone and Tangaraisu Marl. Caught up in the agglomerates along the northern side of the valley are faulted blocks of limestone.

Blue-grey friable pyroclastics, considered to be Toni Tuffs, are exposed at the western end of the Chipakalau Valley, unconformably overlying both the Tangaraisu Marl and a pebbly conglomeratic facies of the Betilonga Limestone.

(c) *Vatuchichi-Talami Headwaters*

This area lies at the southern end of an uplifted block extending from the Betikama to the Chipakalau. The southern end is broken by a system of faults striking 60° and 160° . A belt of Betilonga Limestone and sheared Tangaraisu Marl separates the Basement rocks of the Chipakalau Valley from the mineralised Vatuchichi lode-stuff area which is defined by two intersecting faults: the mineralised area lying within the north-west quadrant.

To the north and north-west the agglomerates have been faulted against the Tangaraisu Marl. In the north-east corner triangular blocks of Betilonga Limestone and Tangaraisu Marl have been faulted into the agglomerates. At the western end of the area the local dip of the sediments has been reversed by a northerly-trending fault.

(d) *Pokipoki-Betisahata Valleys*

At the eastern end of the Pokipoki Valley the sedimentary succession is blanketed by the Toni Tuffs which extend eastward into the headwaters of the Chipakalau. The underlying Tangaraisu Marls dip about 35° eastward and are about 100 ft. thick.

Near the contact between mudstones and the Tina Calcarenite faulting has disturbed the bedding. Downstream to the westward, the dip varies between 20° to 40° and dips as much as 40° westward, except near the Betisahata, where there is a general flattening of the dip. A few hundred feet west of the Pokipoki-Betisahata junction the sediments are underlain by a 100-ft. band of Betilonga Limestone faulted against the Basement Agglomerates.

About 3,000 ft. north-west of the Betisahata-Pokipoki junction a major fault is thought to strike approximately east-west, dropping the Toni Tuffs against the Tina Calcarenite; and it is probable that this is an extension of the east-west fault on the northern side of the Chipakalau Valley.

(e) *Olsen Creek and the Betilonga Headwaters*

The structure in this area is characterised by a clearly defined "rift valley" fault block 1,000 ft. wide, 4,000 ft. long and striking approximately 300° . Except in the north-east the down-faulted Tangaraisu Marls are surrounded by sheared Basement Agglomerates.

The continuity of the east-west trending faults is broken by a series of faults striking north-east. At the eastern end of the rift the two boundary faults diverge and it appears that two "prongs" of mudstone have been dropped into the agglomerates. The western extension of the Olsen Creek Rift is not known, but it would probably be found in the Tohurua Valley north-west of Mangapahu.

The faulted sediments have been heavily sheared parallel to the direction of the two major faults; lineations in the agglomerates adjacent to the faults suggest that they dip steeply towards each other at angles of between 50° and 70° .

At the eastern end of the fault block the beds dip 50° to 60° north-east; westward along the Olsen Creek Valley the sediments dip 20° to 40° north. The Tangaraisu Marls in this area are a remarkably homogeneous formation consisting almost entirely of tuffaceous siltstones and mudstones. Isolated lenses of calcareous conglomerates and grey sandstones interrupt the sequence in a few places.

North-east of Mangapahu Village a triangular block of Betilonga limestone has been faulted into the underlying agglomerates; limestone boulders were found in two of the southern tributaries of Olsen Creek 1,000 ft. east of Mangapahu; the nature of the Olsen Creek contact with the agglomerates is not known, but the boulders probably represent the remains of a down-faulted block.

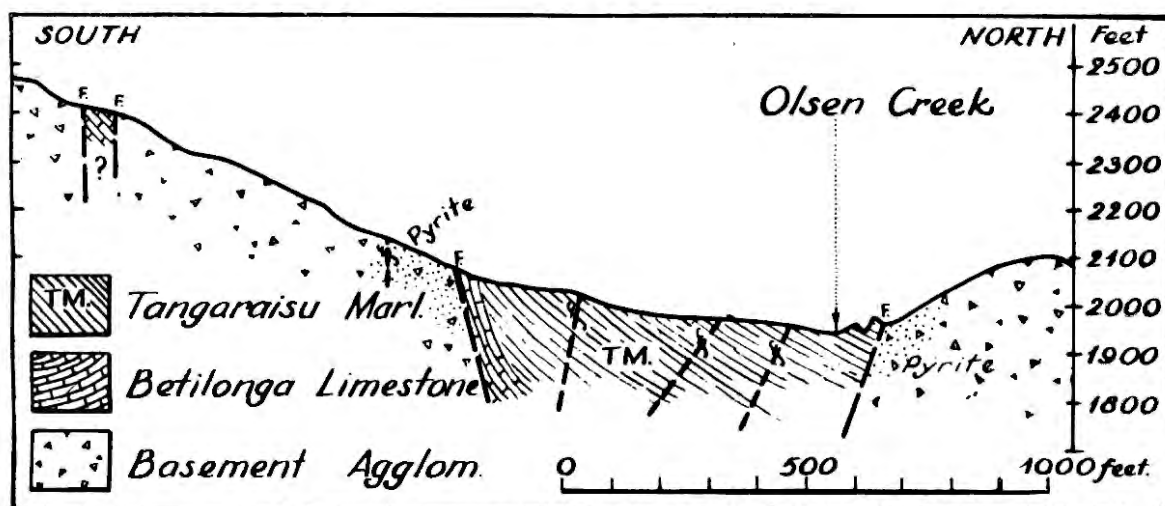


FIG. 45.—Section across Olsen Creek Valley.

6. The Lodestuff Areas

(a) The Olsen Creek and Betilonga Headwaters

Traces of copper, gold and magnetite have been found in this area, and its occurrence appears to be independent of the hard siliceous lodestuff which is only exposed 100 ft. south of the Olsen Creek-Betilonga junction, and at the eastern end of the Olsen Creek Rift along the southward-trending and converging faults.

Boulders of lodestuff are scattered along the course of the Behoa, derived from a number of concealed outcrops as well as from the two outcrops at the western end of the "rift". Approximately 500 ft. south of the Betilonga-Behoa junction blocks of lodestuff between 10 ft. and 15 ft. across are scattered along the valley for about 300 ft. The lodestuff fragments have probably slumped from an outcrop along the fault 500 ft. eastward. 200 ft. further upstream another block of lodestuff 20 ft. across is considered to have slumped from another concealed outcrop at the intersection of two faults 200 ft. to the south-west. 300 ft. south-east of the intersecting faults lie about half-a-dozen lodestuff boulders all between 10 ft. and 20 ft. across, and resting upon highly sheared mudstones; they have apparently slumped from the fault outcrop a few yards westward.

The most impressive exposure of lodestuff lies in the eastern headwaters of the Behoa, and consists of a great block of sheared siliceous material 20 ft. high and 40 ft. across. The bulk of it consists of highly sheared hard grey quartz which spalls off easily as shatter fragments when picked (spec. 3527). Microscopically the material consists of a cryptocrystalline quartz groundmass containing drusy cavities partially filled with quartz crystals. Minute grains of pyrite are scattered throughout the groundmass but not in the quartz fragments. Away from the intensely shattered zone the lodestuff consists of gritty blue-grey gouge, silicified and hardened, and containing disseminated pyrite and milky quartz fragments a $\frac{1}{4}$ in. across. Where seen in three places the lodestuff rests upon sheared and shattered mudstone striking 300° and dipping 60° eastward. Mudstone fragments are exposed

for another 200 ft. upstream, but beyond this only agglomerate fragments were observed. A few fragments of hard siliceous lodestuff lie on the surface in the vicinity of the fault between mudstone and agglomerates. No



PLATE XV

The large block of siliceous lodestuff in Behoa Creek.

depressions could be found, however, from where the large block might have slumped. Many of the large mineralised boulders along the length of the Behoa valley consist of cemented quartz breccias, which are especially abundant along the westerly-flowing portion of the Behoa River.

Magnetite and chalcopryite are found as irregular veinlets and disseminations in the agglomerates adjacent to the northern fault of the Olsen Creek Rift. Generally speaking, however, there is only slight pyritic mineralisation adjacent to the fault zone here, and notable pyritic gouge was only found in two localities, both between 200 ft. and 300 ft. distant from major fault outcrops.

A small amount of fine gold was obtained by panning from the tributaries on the southern side of the Olsen Creek, apparently from the vicinity of the fault zone on the south side of the rift.

7. The Betisahata Valley

Two possible lode-bearing areas have been found a few miles west of Betilonga, but because of their distance apart will be dealt with under two headings.

(i) The Mineralised Area in the Valley of a Southward-flowing Tributary of the Betisahata

A block of ironstained siliceous and pyritic lodestuff lies in the Betisahata river bed at its junction with a

southward-flowing tributary (M.R. 053072). Another block of lodestuff lies in the valley 600 ft. upstream; both these blocks are approximately 20 ft. across.

The agglomerates in the southward-flowing tributary are heavily sheared in many places to a blue-grey pyritic mylonite. Talc veinlets striking north-east and dipping 45° to the south are developed along lines of greatest shear (spec. 3521). Up- and down-stream from the talc-bearing agglomerates the country rock has been invaded by stocks of diorite containing finely disseminated pyrite (spec. 3522).

Boulders of ironstained lodestuff containing barytes similar to that found in the Vatuchichi headwaters lie along the stream bed 600 ft. north of the diorite bodies, and appear to have come from somewhere between two zones of pyritic gouge. North of the lodestuff the gouge has been heavily stained by iron-bearing solutions for approximately 70 ft. along the outcrop. Similar iron-stained fault-gouge was observed along one of the northern tributaries of the Chipakalau headwaters.

More siliceous pyritic lodestuff fragments (probably *in situ*) are scattered across the flattened divide above this valley.

(ii) The Betisahata-Hambusmalus Junction

Lodestuff crops out on both sides of the 600 ft. wide Betisahata as a vein-like body 40 ft. wide, striking 145°

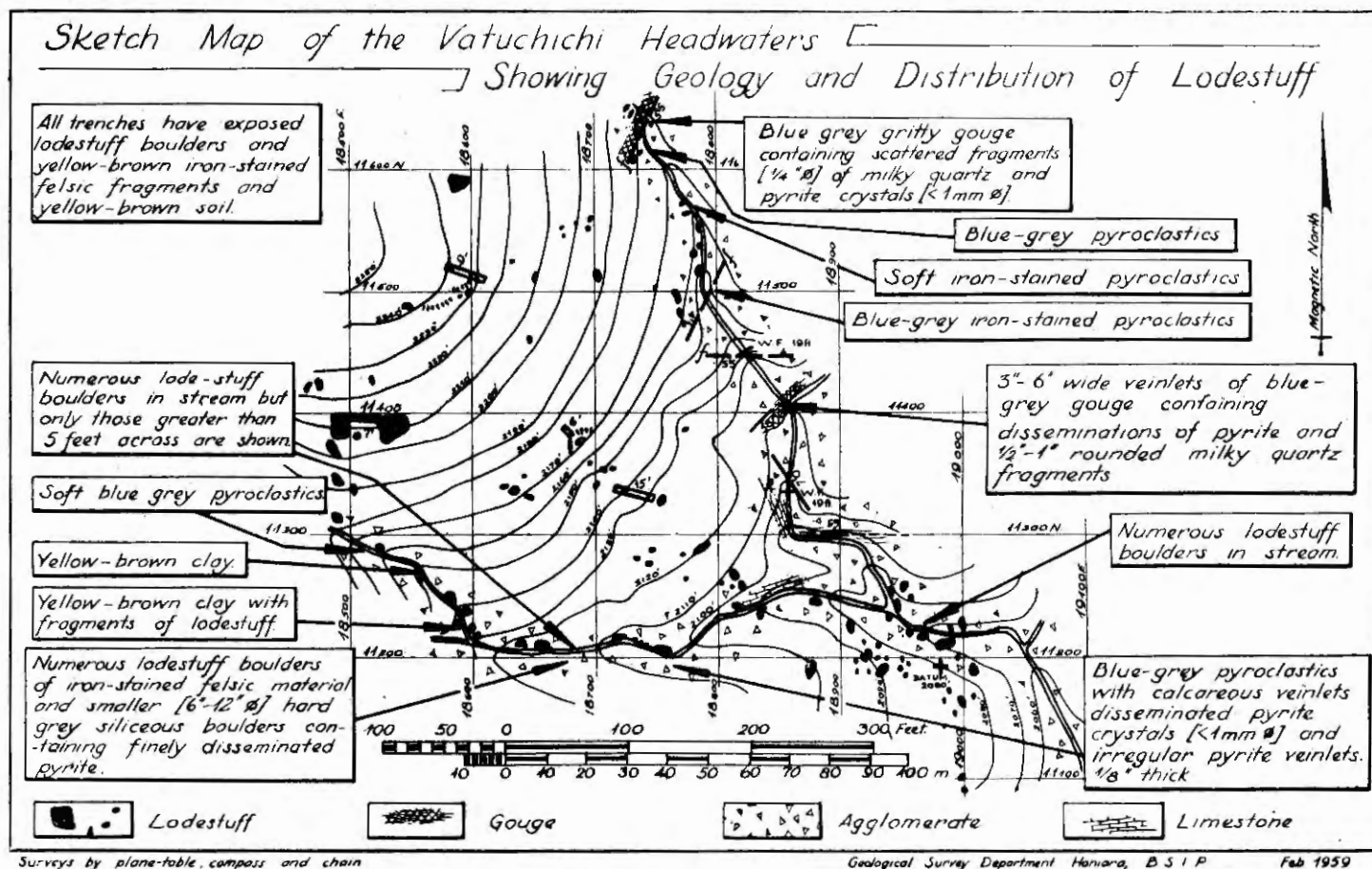


FIG. 46.—Contour map of the hill at Vatuchichi headwaters showing distribution of the blocks of lodestuff.

and dipping 55° west. The vein is distinctly banded and exhibits a progressive alteration from sheared pyroclastics to a core of finely crystalline quartz with visible disseminations and masses of pyrite up to ½-in. across. The following banding is present :—

- Sheared agglomerates.
- Mushy altered agglomerates.
- Blue-grey pyritic gouge containing milky quartz fragments up to 1 in. across.
- Sheared pyritic quartz (spec. 3615) with blue-grey gouge.

The country rock is a sheared and shattered blue-grey agglomerate containing disseminated pyrite. About 75 yards downstream the agglomerates have been altered by a diorite intrusion now exposed along the river bed.

(iii) *The Vatuchichi Headquarters*

The most notable mineralisation observed in the Vatuchichi area was pyrite dissemination and a few malachite films in the sheared agglomerates at the eastern end of the lodestuff area. Numerous large blocks of lodestuff are exposed on the ridges and in the valleys of the western headwaters of the Vatuchichi. The lodestuff crops out in the centre of an upfaulted block of Basement Agglomerates extending 3,000 ft. from north to south and 4,000 ft. from east to west. The surrounding agglomerates have suffered considerable shearing and alteration, and pyritic fault gouge is widespread. This large upfaulted block has been divided into four unequal quadrants by two faults intersecting at right angles. The lodestuff crops out in the north-west quadrant and covers an area of approximately 900 square yards.

There are three distinct types of lodestuff associated with this deposit :—

- (1) Hard ironstained but mostly light-coloured material containing barytes.
- (2) Hard dark grey quartz containing much disseminated pyrite.
- (3) Blue-grey pyritic gouge containing milky quartz fragments between ¼ in. and 1 in. across.

The ironstained light-coloured oxidised material is exposed as boulders up to 20 ft. across, scattered over an area between the Vatuchichi and two of its headwater tributaries. Many of the larger blocks appear to be *in situ* or approximately so (spec. 3581, 3582). No pyrite was observed in any of them.

Surrounding the central core of the hard ferruginous lodestuff on this Vatuchichi hillside is a well-defined zone of quartz fragments. Shear lines in this material strike north-south and dip steeply eastwards. Faulted blocks of limestone have been caught up in this zone. Fragments of ironstained weathered lodestuff (spec. 3513) were found west of the pyritic gouge but only in small quantities.

The valley floors in this region are littered with numerous hard ironstained siliceous lodestuff boulders invariably containing much finely disseminated pyrite.

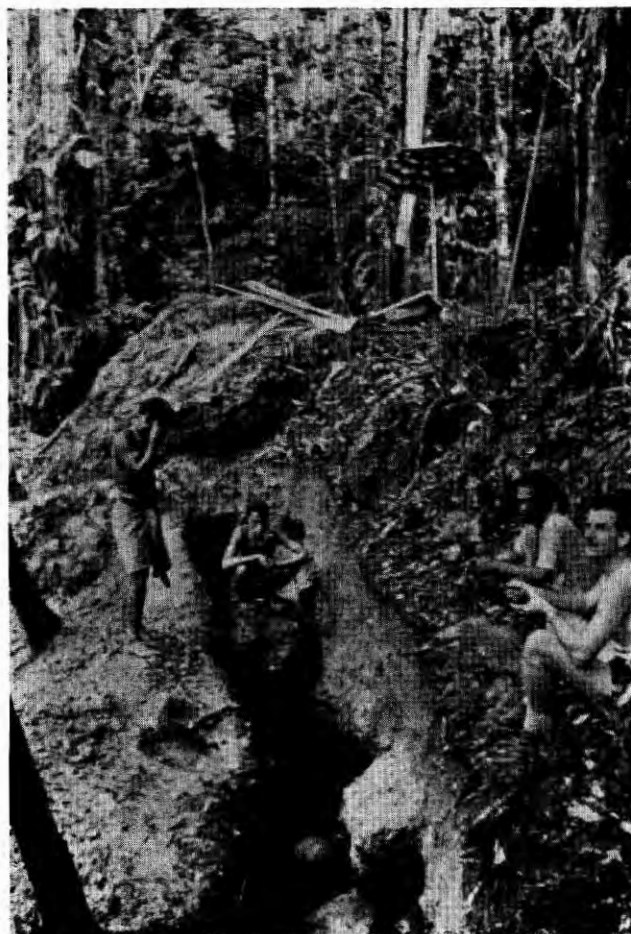


PLATE XVI

Trenching between large blocks on Vatuchichi Hill.

No extensive outcrops were found, but fragments up to 6 in. across were seen within the bands of blue-grey pyritic gouge. In the stream, blocks of this siliceous lodestuff measured up to 5 ft. across (spec. 3507, 3511).

West of the Vatuchichi area, at a distance of 1,000 ft., an ironstained lodestuff body crops out along the fault for about 30 ft. between Basement Agglomerates and Tangaraisu Marl (spec. 3583, 3584). Trending in a north-easterly direction from the outcrop are blocks of lodestuff suggesting that faulting has truncated a south-westerly trending body of this material lying within the agglomerates. This mineralised body was about 16 ft. in thickness (samples Nos. 6, 7, 8).

(iv) *The Chipakalau Valley*

No continuous outcrops of lodestuff were uncovered in the Chipakalau Valley, but there are a number of large, very hard blocks of mineralised material along the valley floor, and within the sheared agglomerates a few hundred feet south of the fault zone. It is now thought that these large silicified blocks may be from vertical masses at fracture junctions and only occur at irregular intervals along or close to the fault zone.



PLATE XVII

Large blocks of very hard siliceous lodestuff such as this are found in the Chipakalau Valley not far from the fault line.

There are three main concentrations of lodestuff lying along the valley over a distance of approximately 1,200 ft. The most easterly occurrence lies less than 100 ft. south of the main fault and consists of a number of large boulders (up to 10 ft. across) of cemented fragments of milky quartz embedded in blue-grey pyritic gouge. Malachite films are scattered through this material. Four large blocks of ironstained lodestuff lie in the stream 800 ft. westward. These, again, cannot be far from their source. The underlying rock is a sheared pyritic agglomerate. Approximately 400 ft. further west a single block of ironstained lodestuff 20 ft. across is deeply embedded in the alluvium; the nearby country rock is blue-grey pyritic fault gouge.

The three concentrations are roughly in a straight line but are apparently discontinuous—no sign of any lode material was found between the three occurrences.

Scattered along the Chipakalau and its northern tributaries are numerous discontinuous blocks of hard ironstained siliceous and mineralised material which probably originates from the extensive areas of blue-grey pyritic gouge adjacent to the faults.

8. Economic Materials

No deposit of economic interest was found in the Betilonga Basin, but indications suggest that sizeable bodies could exist. Details of location of lodestuff are given with map reference in the Appendix. The following minerals were found—gold, pyrite, magnetite, chalcopryite, malachite, talc and barytes. All these were in the basement rocks, the sedimentary formations being apparently barren. A few grains of chalcopryite were

also seen in the andesitic pebbles of the Betilonga Limestone conglomerate facies.

(a) Gold

Alluvial gold washed from the basement rocks has been obtained from the Betilonga and its tributaries. The gold is extremely finely divided with occasional grain size of 1 mm.; very rarely to 2 mm. In the Olsen Creek fine gold was obtained from pot-holes in the Tangaraisu Marls, its place of origin being the sheared agglomerates adjacent to the east-west trending fault on the southern side of the Olsen Creek Valley.

(b) Pyrite

This mineral is widely scattered through the Basement Agglomerates and concentrated both in the blue-grey fault gouge and in the siliceous ironstained lodestuff around the Betilonga Basin. It is also associated with talc and magnetite veinlets. The pyrite usually occurs in disseminated form, mostly concentrated in the gouge areas and decreasing outward from the zone of disturbance. It is also found as individual grains up to 2 mm. across and as crystalline aggregates a few centimetres across.

The most extensive pyrite disseminations occur around the faulted Vatuchichi lodestuff and in the sheared agglomerates on the northern side of the Chipakalau Valley. In the Vatuchichi area no pyrite was found in the ironstained felsic material although it was found all round it. The agglomerates around the Olsen Creek Rift, however, are comparatively free from pyrite, which was only observed at the intersection of the two main east-west faults with a transverse fault trending north-east to

south-west. It also occurs in the valley of the northward-flowing Olsen Creek tributaries. Pyrite was almost completely absent in the Vurakuvekuve Valley and at the extreme western end of the Chipakalau Valley. Intense shearing was also absent here.

At the extreme western end of the region, in a southward flowing tributary of the Betisahata, disseminated pyrite is scattered through sheared agglomerates invaded by a pyrite-bearing diorite.

At the junction of the Betisahata and Hambusmalus (see Part I) the agglomerates are cut by a 40-ft.-wide vein of quartz lodestuff containing much pyrite in segregations up to $\frac{1}{2}$ in. long as well as disseminated. The agglomerates have been invaded by diorite 100 yards downstream.

(c) *Magnetite*

Veinlets of magnetite have only been found in the sheared agglomerates on the eastern side of the Betilonga 100 yards beyond its junction with Olsen Creek. The magnetite bodies are irregular and discontinuous lenses, a few inches in length and $\frac{1}{2}$ in. wide. Disseminated pyrite is associated with the magnetite.

The people of Mangapahu have reported the existence of a heavy black rock west of the village; time did not permit a visit to this occurrence.

(d) *Chalcopyrite and Malachite*

Chalcopyrite was found at the western end of the Chipakalau Valley and on the northern slopes of the Olsen Creek Valley. In both places the chalcopyrite lies in sheared pyritic agglomerates in the vicinity of two intersecting faults. The mineral is found as dense aggre-

gates of chalcopyrite crystals, as distinct crystals, and as fine disseminations closely associated with pyrite. Both these occurrences were shown by pitting to be no more than isolated masses; but the possibility of more chalcopyrite with depth in the vicinity of these intersecting faults cannot be ignored.

Malachite stains were found in the agglomerates on the eastern side of the Vatuchichi lodestuff area, and in the tributary valleys on the southern side of the Chipakalau.

A sheared agglomerate boulder, rich in bornite, chalcopyrite and pyrite (spec. 3585) was found in a tributary of the Betilonga 1,000 ft. south of Betilonga Village.

(e) *Talc*

An unusual sugary variety of talc (spec. 3516, 3517, 3521) was found in two widely separated localities. In both places the host rock is an intensely sheared pyritic agglomerate, but the cause of the shearing is different. That in the Chipakalau Valley lies a few hundred feet south of the major east-west fault, while that at the western end of the area lies within pyritic agglomerates between two diorite intrusions. The talc is in the form of short irregular veinlets a few inches wide filling shear planes and fractures. The zone containing the talc veinlets is not more than a few feet across and appears to form vertical pockets rather than continuous lines of mineralisation laterally.

(f) *Barytes*

This mineral has been found in many lodestuff blocks and boulders at the western end of the Chipakalau Valley.

APPENDIX TO REPORT No. 21—PART II

LOCATION OF LODESTUFF AND DETAILS OF SAMPLING IN THE BETILONGA AREA

Hard ironstained light-coloured material, apparently free from pyrite, and blue-grey pyritic gouge containing milky quartz fragments, have been found adjacent to zones of intense shearing: but only in the Basement Agglomerates. The material is found as isolated bodies and enormous blocks which could not be traced for any distance because of the nature of the country.

(i) *Vatuchichi Area*: (Map reference eastings first)

- (a) M.R. 171118: a 16-ft. wide body faulted against Tangaraisu Marl.
- (b) M.R. 185115: an area of 600 square yards of lodestuff lying in Basement Agglomerates.

(ii) *Chipakalau Valley*:

- (a) M.R. 170082: blocks of milky quartz lodestuff lying in pyritic agglomerate.
- (b) M.R. 164082: isolated blocks of hard felsic lodestuff 10 ft. across lying in alluvium.
- (c) M.R. 159080: isolated block of ferruginous lodestuff 20 ft. across lying in alluvium.

(iii) *Behoa Valley*:

- (a) M.R. 249017: blocks of lodestuff 10 ft. across, concentrated along the mudstone floor of the valley; probable origin from the agglomerates about 600 ft. eastward.
- (b) M.R. 247013: block of lodestuff roughly 20 ft. across, probable origin near intersection of faults 200 ft. westward.
- (c) M.R. 249011: blocks of lodestuff 10 ft. across, probably close to their source.

- (d) M.R. 256012: block of siliceous lodestuff 40 × 20 × 20 ft., resting on mudstone. Derived from the agglomerates 200 ft. eastward.

(iv) *Olsen Creek*:

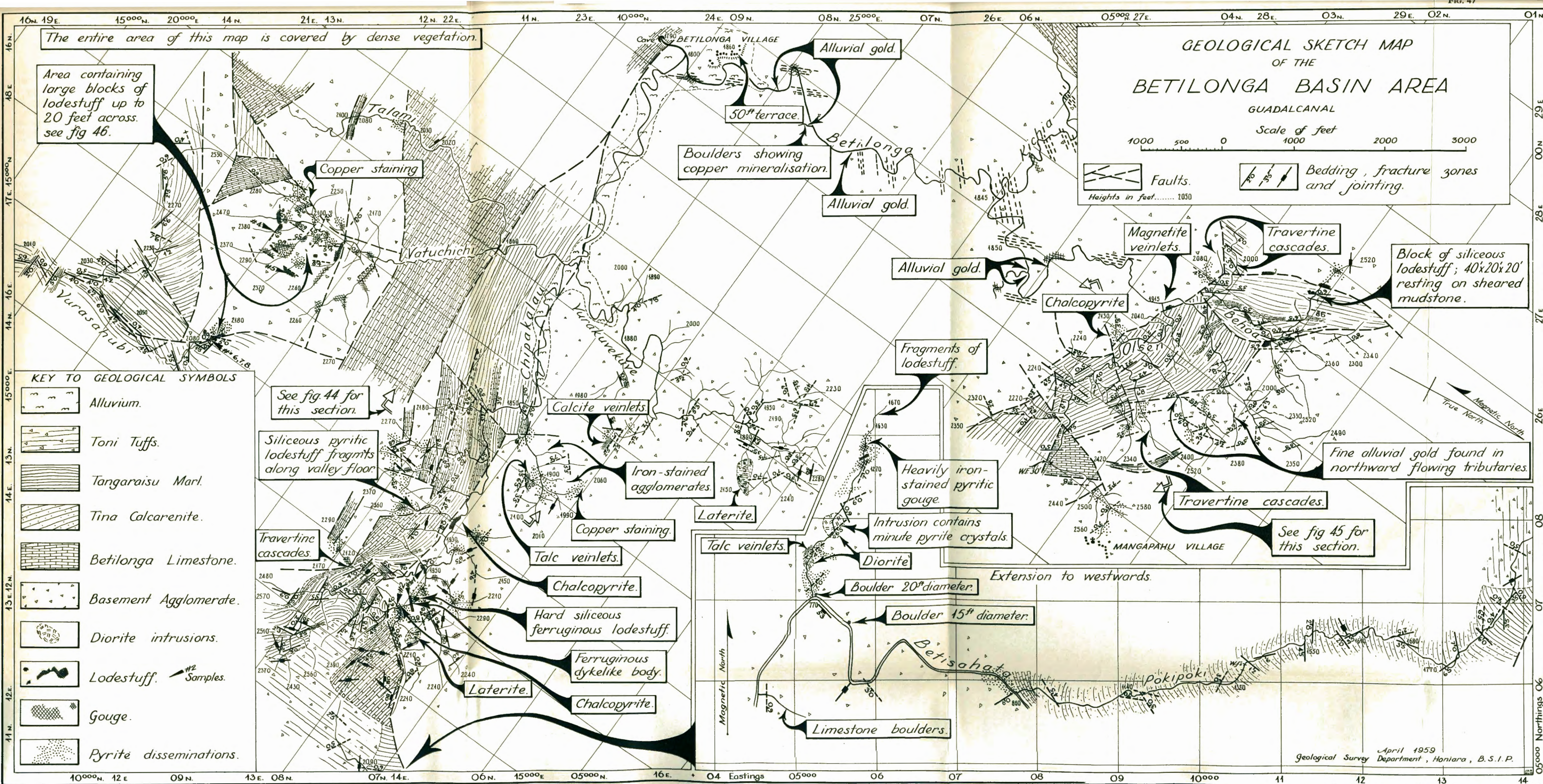
- (a) M.R. 245025: blocks of lodestuff 5 ft. across are exposed on the spur 200 ft. south of the Olsen Creek-Betilonga junction. These are apparently *in situ* adjacent to the northern fault of the Olsen Creek "rift".

(v) *Betisahata River Valley*:

- (a) M.R. 059087: blocks of lodestuff 10 ft. across lying between two zones of blue-grey pyritic fault gouge. The flattened divide upstream from this exposure is littered with smaller blocks of lodestuff.
- (b) At the junction of the Betisahata and Hambusmalus Rivers. A 40-ft.-wide vein of siliceous pyritic lodestuff is located close to a major fault and adjacent to a pyrite bearing diorite.

Two small but significant areas of copper concentrations were found at the western end of the Chipakalan Valley (M.R. 157081) and on the northern side of the Olsen Creek Valley (M.R. 237028). At these places masses and disseminations of chalcopyrite lie in the sheared agglomerates near a system of intersecting faults. Only a small amount of chalcopyrite was exposed, but the possibility of finding more at a greater depth in this area cannot be ignored.

Sample No.	Location	SAMPLE DETAILS	
		Sample Length and Type	Remarks
1	Western Chipakalau (M.R. 164082)	Grab	Blue-grey sheared pyritic agglomerate with traces CuCO_3 .
1A	Western Chipakalau (M.R. 164082)	Grab	Blue-grey pyritic gouge with traces of CuCO_3 .
2	Western Chipakalau (M.R. 157081)	Channel 4 ft.	Blue-grey pyritic gouge.
3	Western Chipakalau (M.R. 159080)	Channel 4 ft.	Hard ferruginous lodestuff.
4	Vatuchichi Headwaters (M.R. 186119)	Channel 2 ft.	Pyritic milky quartz fault breccia.
5	Vatuchichi Headwaters (M.R. 183117)	Grab	Grey pyritic gouge.
6	Vurasahubi Headwaters (M.R. 171118)	Channel 12½ ft.	Slightly ironstained hard felsic lodestuff. From southern end of the face of outcrop of enormous block weighing hundreds of tons.
7	Vurasahubi Headwaters (M.R. 171118)	Channel 12½ ft.	Heavily ironstained hard felsic lodestuff containing scattered granules of milky quartz. From central part of the face of above outcrop.
8	Vurashubi Headwaters (M.R. 171118)	Channel 10 ft.	Slightly ironstained felsic material. From northern part of the face of same outcrop.
9	Behoa Valley (M.R. 256012)	Channel 63 in.	Hard blue-grey gritty lodestuff containing milky quartz fragments and disseminated pyrite. Western end of enormous block weighing several hundred tons.
10	Behoa Valley (M.R. 256012)	Channel 66 in.	Shattered ironstained grey quartz and milky quartz fragments set in a blue-grey pyritic gouge. Northern end of same exposure.
11	Behoa Valley (M.R. 256012)	Channel 60 in.	Hard blue-grey pyritic gouge containing milky quartz granules and scattered hard grey rounded quartz fragments. From western end of same exposure.
12	Behoa Valley (M.R. 256012)	Channel 48 in.	Shattered grey quartz containing fine pyrite. From southern end of same exposure.
13	Betisahata-Hambusmalus Junction	Channel 6 ft.	Shattered grey quartz lying in blue-grey pyritic gouge.



SEISMIC AND VOLCANIC ACTIVITY IN THE SOLOMONS DURING 1957-58

By J. C. GROVER

1957

During 1957 earthquakes were recorded at only three epicentres in the main islands of the Protectorate. There was activity at 10 epicentres in the Santa Cruz Group during the same time. Many more shocks occurred in Bougainville and the area to the north-west.

* * *

Regular observations of temperatures were made on Savo during the year, temperatures between 97°C. and 103°C. being recorded. Dr. Fisher, Chief Geologist of the Australian Bureau of Mineral Resources, visited the crater during his second visit to the Protectorate in September 1957.

A report was received in late December* that Tinakula Volcano (near Santa Cruz), after a period of quiescence,

* From the District Commissioner, J. L. O. Tedder, in his ensuing quarterly report.

had been seen "smoking" about a third of the way down the south-eastern slopes. The activity was, however, only temporary. A report was also received from Vella Lavella to the effect that more steam could be seen rising from the Parasa solfatara area. This has not been confirmed.

* * *

Tsunamis were reported in November 1957 from Malaita : from Afio, and from Fauabu, where the waves were estimated by an observer to be about 9 ft. high at low tide.

1958

The year was again notable for the very few recorded earthquakes in the main islands of the Protectorate, those that occurred being confined to a small area between Guadalcanal and eastern San Cristoval. These were of shallow origin, except one at a depth of 100 km.

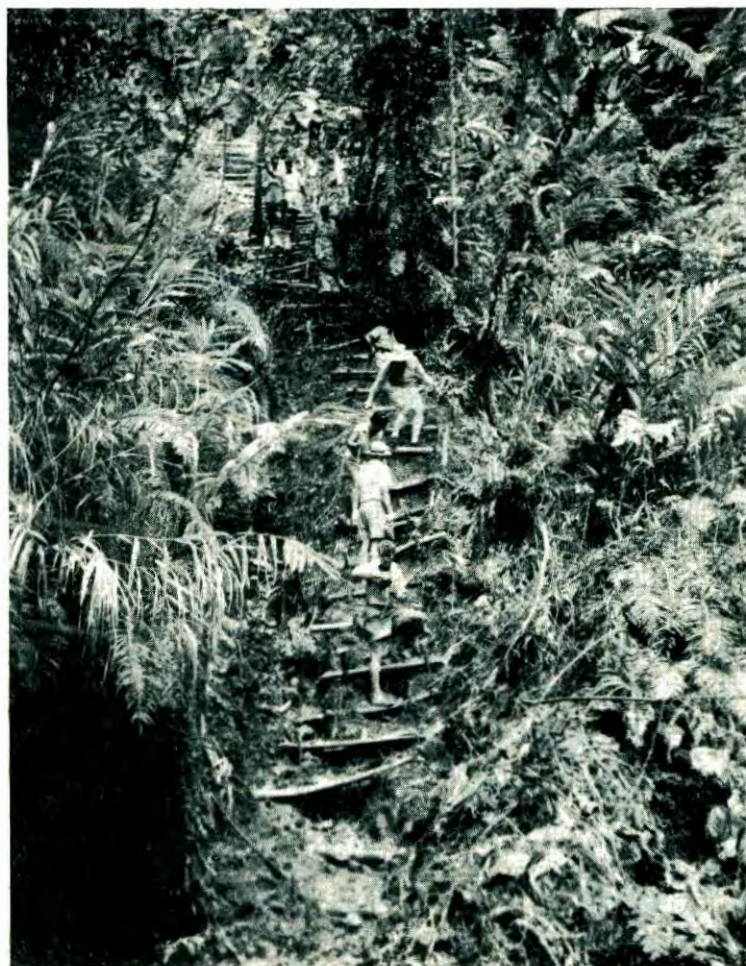


PLATE XVIII

The party descending the stairway on the outer slope of the inner subaerially-deposited crater rim. The fern vegetation shown is typical of that adjoining thermal areas : further away there is an increasing density of forest.

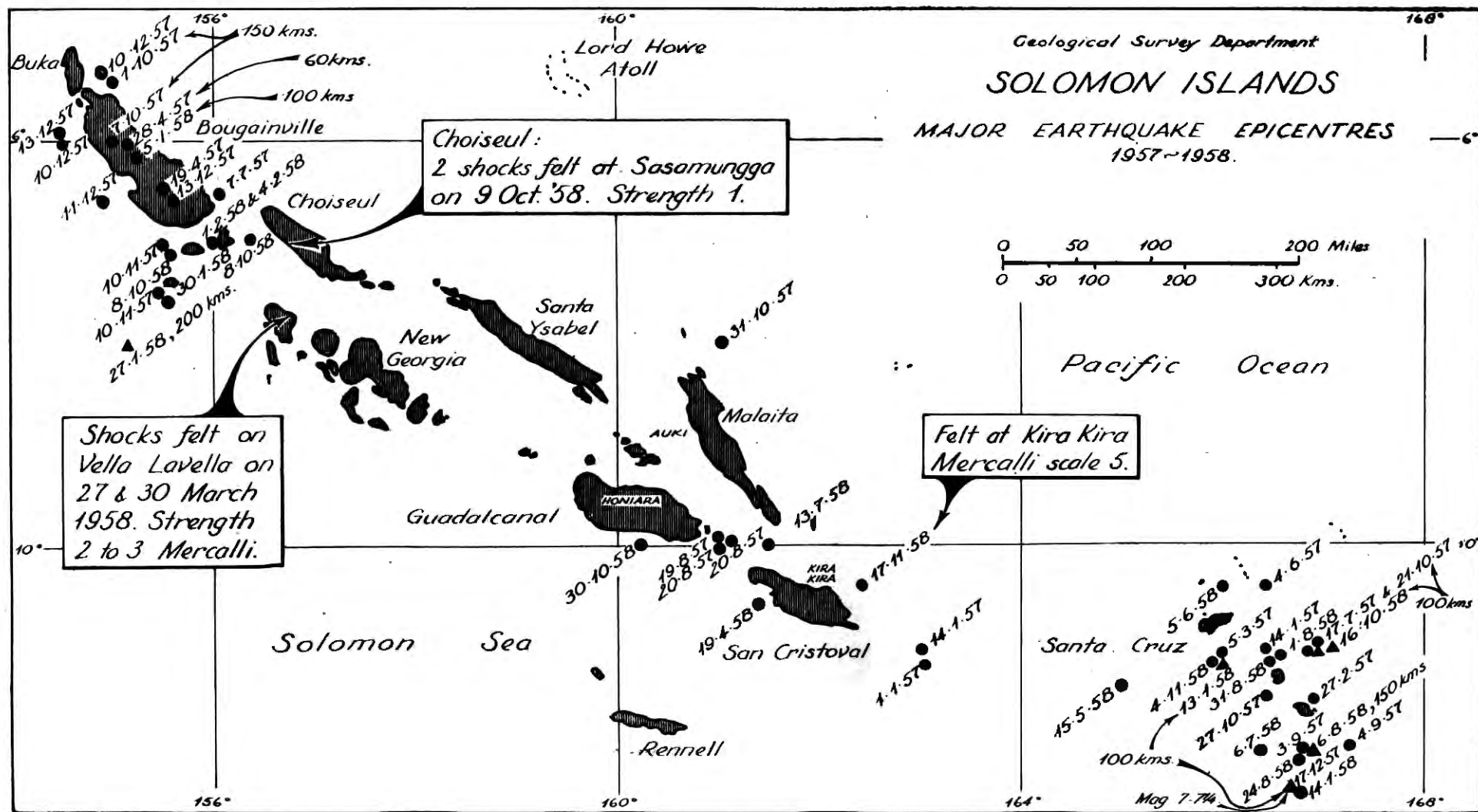


FIG. 48.—Map showing Earthquake Epicentres 1957-1958.

Commissioner visited the central crater of the volcano*. There had been a slight tectonic tremor on the previous night†, and during this visit the island rumbled (with very slight vibration noticeable only when on the crater rim) about three times an hour. This had not been noted in 1956 or 1957.

In March a simple shock recorder was installed‡ on a concrete block in a small building on the east coast of Savo as a temporary measure. Of inadequate sensitivity, the instrument is only able to record shocks felt by

The submarine volcano south of Vangunu in the New Georgia Group was observed in eruption on two occasions during the year. On November 21st at 0120 hours S.I. time the M.V. *Aros*, en route from Rabaul to Honiara, reported eruptions, with flames appearing every 20 seconds approximately, and what appeared to be an island at 6 miles distance was picked up by the ship's radar.

On December 2nd the Qantas aircraft, with geologist Pudsey-Dawson abroad, was diverted to make observa-



PLATE XX

Savo Shock Recorder Station is established at Paibeta on the east coast of the volcano (unfortunately not in the most suitable of locations).

persons. Subsequently an application was made for funds to permit installation of a seismological station at Honiara (20 miles distant) of sensitivity sufficient to detect a re-awakening of Savo. In event of such renewal of activity a *nuée ardente* eruption is expected, and the earliest possible warning is desirable in order that the population might be evacuated.

* Sir John Gutch with District Commissioner and Chief Geologist, on January 21st.

† Felt in Honiara also.

‡ By P. A. Pudsey-Dawson.

tions. The sea was dead calm and the billowing cloudy yellow-green area was circled and photographed in colour. A small patch of very shallow water appeared centrally situated, and the observer commented that if the tide were high at the time, then there seemed a good chance that low tide might have shown an exposure. There was no spray or steam, but from the underwater "billowing" nature of the cloudy discolouration, it was inferred that an eruption might have occurred not long before the arrival of the aircraft.

The area is given a wide berth by shipping, and was

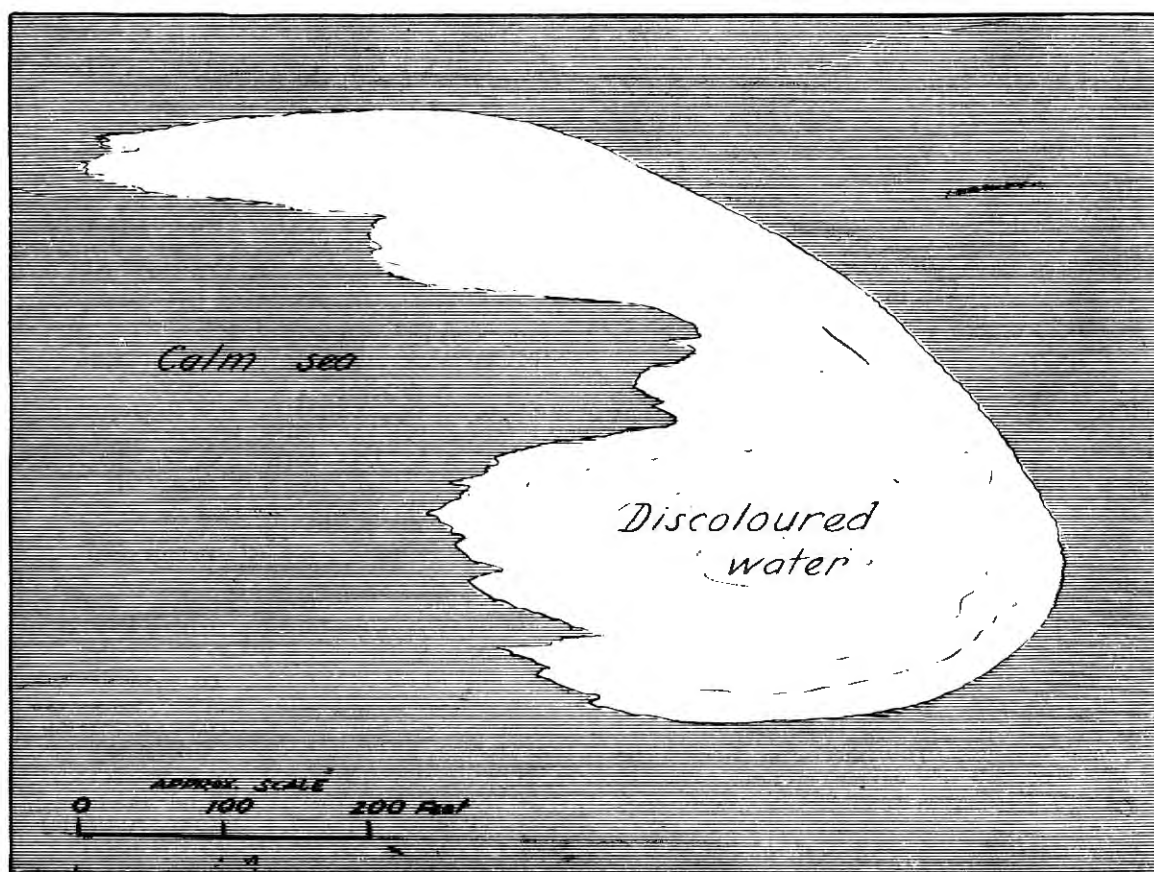


FIG. 49.—Sketch of the sea area surrounding the submarine volcano, as drawn from coloured photographs.

excluded from the area of hydrographic survey by H.M.S. *Cook*. To date no detailed observations of this underwater volcano have been possible.

* * *

Further hot spring areas have been discovered during the year.

Near the mouth of the Pue Pue River at Kira Kira Station is a warm spring of water at the bottom of the main stream, whose source is obscured by alluvium.

One hot spring was reported on Santa Cruz near Napir Village, on the south coast, east of Nabalue. Another occurs on nearby Lord Howe Island, near the head of a stream which flows into the lake.

Yet another hot spring was discovered on Guadalcanal—in the course of detail mapping south of the Betilonga area. Its position is shown on the map in Report No. 21 of 1958.

LIST OF EARTHQUAKE EPICENTRES IN SOLOMONS REGIONS 1957

(From U.S.C.G.S. *Seismological Bulletin*)

Date	Origin Time	Position	Area, Focal Depth, Remarks
1957	G.M.T.	Lat. Long.	
	h. m. s.		
Jan.:			
4	13 38 00	? ?	Solomons region, h about 100 km.
4	15 51 25	? ?	Solomons region.
14	00 28 38	11S 163E	E of San Cristoval.
22	12 31 54	11S 166½E	SE of Santa Cruz.
Feb.:			
5	15 57 27	11S 166E	S of Santa Cruz.
27	16 07 58	11½S 167E	Vanikoro.
Mar.:	Nil		
Apr.:			
19	08 39 37	6½S 155½E	Bougainville. Felt Buin.
20	00 09 10	? ?	
28	10 36 41	6S 155E	Bougainville, h about 60 km.
May:	Nil		
June:			
0	11 14 50	10½S 166½E	NE of Santa Cruz.

Date	Origin Time	Position	Area, Focal Depth, Remarks
1957	G.M.T.	Lat. Long.	
	h. m. s.		
July:			
7	16 11 15	6½S 156E	E Bougainville, nr. Kieta. Felt at Rabaul. Mag. 6½.
17	11 10 10	11S 167E	ESE of Santa Cruz.
Aug.:			
15	20 45 20	4½S 155E	N of Bougainville, h about 500 km.
16	11 57 16	5S 155E	N of Bougainville.
	12 07 04	5S 155E	Felt also in Rabaul.
19	11 34 36	10S 161E	SE coast Guadalcanal. Mag. 6½.
20	06 27 07	10S 161E	SE coast Guadalcanal. Mag. 6-6½.
20	12 01 54	10S 161E	SE coast Guadalcanal. Mag. 6.
23	02 00 09	6S 154½E	Bougainville, h about 60 km. Mag. 6½.
23	13 33 51	6S 154E	W of Bougainville, h about 100 km.

Date	Origin Time	Position	Area, Focal Depth, Remarks
1957	G.M.T.	Lat. Long.	
	h. m. s.		
Aug.: 26	19 53 33	5½S 154E	W of Bougainville, h about 100 km.
Sept.: 3	06 06 42	12S 167E	S of Vanikoro.
4	01 31 23	12S 167½E	SE of Vanikoro.
15	18 42 20	6S 153½E	W of Bougainville, h about 150 km.
Oct.: 1	07 12 26	5½S 155E	N of Bougainville, h about 100 km.
7	07 31 14	7S 155E	S of Bougainville, h about 150 km.
21	00 17 25	11S 167E	ESE of Santa Cruz, h about 100 km.
27	22 56 55	11½S 166½E	WNW of Vanikoro.
31	04 24 04	8S 161E	N of Malaita.

Date	Origin Time	Position	Area, Focal Depth, Remarks
1957	G.M.T.	Lat. Long.	
	h. m. s.		
Nov.: 8	02 46 22	5½S 155E	N of Bougainville, h about 150 km.
9	19 10 39	? ?	
10	02 36 21	7S 155½E	S coast Bougainville.
10	03 43 49	7½S 155½E	S coast Bougainville, near Treasury.
Dec.: 10	15 53 02	5½S 155E	N of Bougainville, aftershock.
11	03 38 44	6½S 155E	Mid-west coast Bougainville, aftershock.
13	02 27 45	6S 154½E	W of Bougainville, aftershock.
13	20 03 58	6½S 155½E	Bougainville, aftershock.
17	13 50 12	12½S 166½E	S of Vanikoro, h about 100 km. Mag. 7-7½.

LIST OF EARTHQUAKE EPICENTRES IN SOLOMONS REGION 1958
(From U.S.C.G.S. Seismological Bulletin)

Date	Origin Time	Position	Area, Focal Depth, Remarks
1958	G.M.T.	Lat. Long.	
	h. m. s.		
Jan.: 5	12 28 20	6S 155E	Bougainville: felt in Rabaul, depth about 100 km.
8	? ? ?	? ? ?	Two shocks in Honiara not recorded overseas.
13	02 54 37	11S 166E	S of Santa Cruz; depth about 100 km.
14	15 00 14	12½S 167E	S of Vanikoro.
18	19 24 30	6S 155E	Bougainville: depth about 100 km.
20	? ? ?	? ? ?	Two shocks in Honiara not recorded overseas.
27	08 52 42	8S 155E	Solomon Sea, S of Bougainville; h = about 200 km.
30	06 13 24	7½S 155½E	Near Treasury Is., mag. 6½.
Feb.: 1	22 00 15	7S 156E	Shortland Islands.
4	00 02 16	6½S 155E	S of Bougainville.
4	12 40 27	7S 156E	Shortland Islands.
15	? ? ?	? ? ?	Shocks at 0855 G.M.T. felt on San Cristoval not recorded overseas.
16	23 54 45	6S 155E	Bougainville.
Mar.: 20	14 47 05	10S 161E	E of Guadalcanal.
27, 30	? ? ?	? ? ?	Shocks felt at Vella Lavella were not detected overseas.
Apr.: 2	10 50 42	5½S 154½E	W of Bougainville.
17	02 01 26	6S 154E	W of Bougainville.
	02 15 16	10S 152½E	Solomon Sea S of Bougainville.
	06 21 43	6S 155E	Bougainville.
	16 42 21	6½S 154½E	S of Bougainville.
19	10 49 50	10½S 161½E	Off SW corner of San Cristoval.
22	21 12 45	? ?	Solomons Region.
May: 15	07 01 56	11½S 165E	SW of Santa Cruz.
30	05 50 26	7S 154½E	S of Bougainville.
June: 5	08 21 07	10½S 166E	N of Santa Cruz.
July: 13	12 03 50	10S 161½E	Off South Malaita: depth about 100 km.: shocks felt on Malaita and Florida Group. This was the day following the several explosions reported by island-

Date	Origin Time	Position	Area, Focal Depth, Remarks
1958	G.M.T.	Lat. Long.	
	h. m. s.		
July:			ers in widely separated places which caused speculation at the time of the loss of R.C.S. <i>Melanesian</i> .
16	16 54 17	12S 166½E	SW of Vanikoro.
16	18 40 21	12S 166½E	SW of Vanikoro.
23	11 44 00	? ?	Solomon Islands region.
Aug.: 6	14 23 25	? ?	Solomon Islands region.
6	21 51 00	12S 167E	S of Vanikoro, Santa Cruz Group h = 150 km.
13	19 21 21	? ?	Solomon Islands region.
23	07 59 09	12S 167E	S of Vanikoro again.
26	15 57 57	12S 167E	S of Vanikoro. Depth 150 km.
31	16 19 57	11S 166½E	SE of Santa Cruz.
Sept.: 2	02 56 34	6½S 155E	Bougainville area.
4	19 30 ?	? ?	Shocks felt on San Cristoval not recorded overseas.
7	04 40 57	10S 153E	Solomons Sea SW of Bougainville.
	04 43 37	9½S 152½E	Solomons Sea SW of Bougainville.
8	13 58 19	? ?	Santa Cruz Islands region.
20	17 09 24	6½S 154½E	SW of Bougainville.
28	12 50 25	5S 153½E	New Britain-Bougainville area. Depth 100 km.
Oct.: 1	06 31 33	11S 166½E	SE of Santa Cruz.
8	14 00 47	7S 155½E	S of Bougainville.
	14 24 47	7S 156½E	Between Choiseul and Fauro.
16	18 02 01	11S 167E	ESE of Santa Cruz. Depth 100 km.
30	23 04 39	10S 160½E	Off S coast of Guadalcanal.
Nov.: 4	19 55 11	11S 166E	Off S coast of Santa Cruz.
11	22 30 ?	? ?	Shock force 3 felt on Vella Lavella was not recorded overseas.
17	09 46 30	10½S 162½E	Off NE coast of San Cristoval, was felt at Mercalli scale force 5 at Kira Kira Station where crockery suffered.
Dec.: 13	09 05 55	4½S 153½E	N of Bougainville.
22	92 17 14	6S 155E	Bougainville.

A NOTE ON OCEAN CURRENTS IN THE SOLOMONS, INFERRED FROM THE RECOVERY OF WRECKAGE OF THE R.C.S. *MELANESIAN*, LOST IN JULY 1958

By J. C. GROVER

The R.C.S. *Melanesian*, of 300 tons, the largest and best-equipped vessel in the Solomons, 100 A1 at Lloyds after survey five months previously, was not heard of after 0900 hours on Thursday, July 10th. Attempts to contact by radio on the morning and afternoon of the 11th were unsuccessful, but no alarm was felt until Saturday, the 12th, when an all-out search was begun. Two aircraft and about 30 vessels took part during the ensuing weeks.

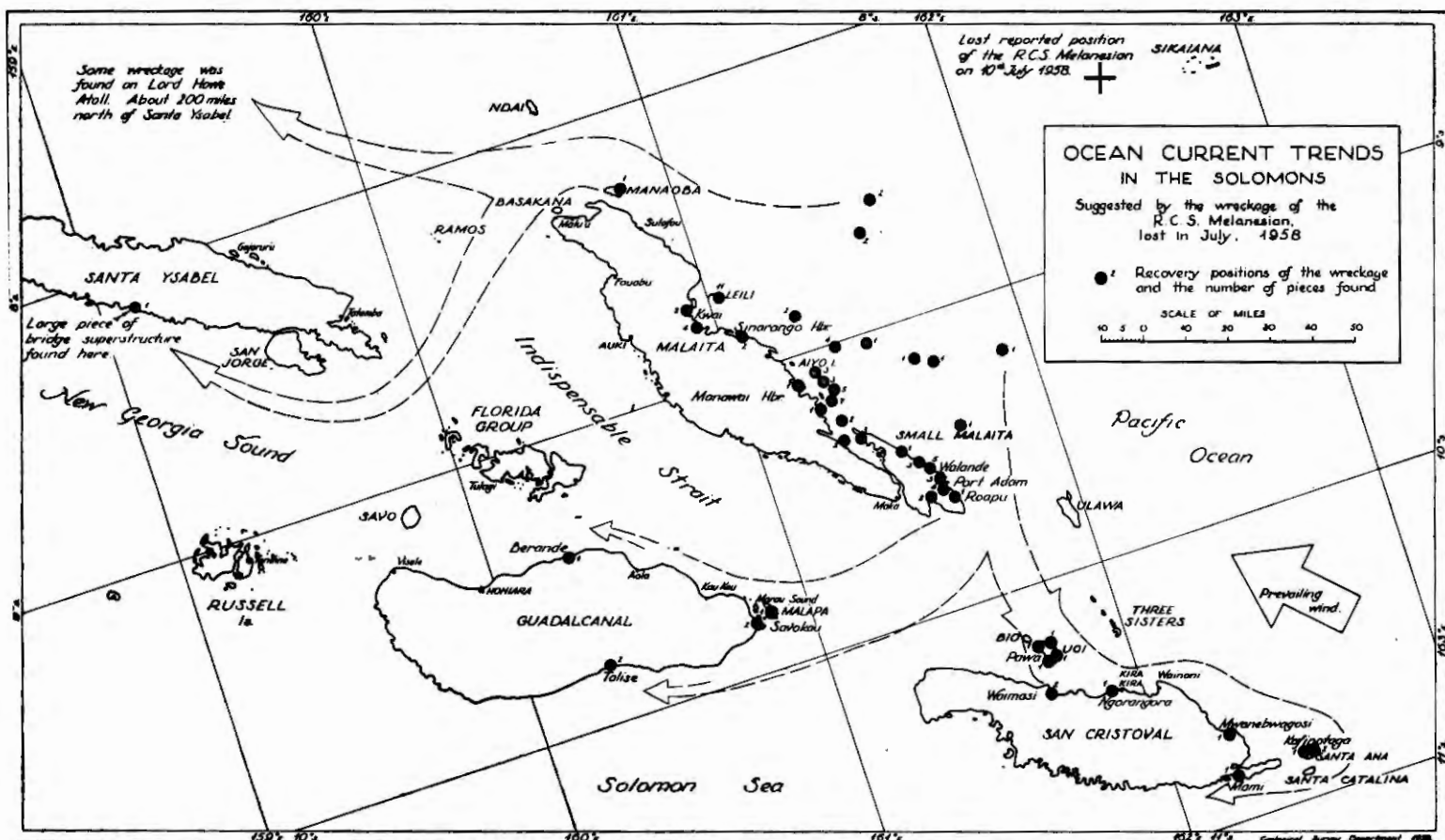
The first wreckage was found on Friday, the 18th, and the search was discontinued on Tuesday, the 22nd. The wreckage floating at sea was picked up during this period, as well as much of the shore-stranded items. The only body of the 62 persons on board was found on Sunday, the 20th.

As there was no reliable data at the time regarding the ocean currents, and the opinions of persons who had known the Solomons for scores of years varied just about as widely as possible, it was necessary to search in all

directions by ship and plane, with consequent ineffectiveness and loss of time, in spite of the unsparing efforts made and the efficiency of the central direction.

In this island territory, where shipping and canoes sometimes get into difficulties or disappear without trace, search is hampered by lack of knowledge of ocean currents: this is a serious drawback where time is so all-important, and such vast areas of the sea are involved. Any data that becomes available which might be of value in this regard should be placed on record as soon as possible.

On February 28th, 1956, the Solomons was the scene of another lesser tragedy, when the A.V. *Arakarimoa* drifted in to the south coast of Guadalcanal with 20-odd starving islanders on board from the Gilberts: from where, on a 25-mile trip between islands, the ship had been reported missing since December 28th, exactly two months previously. They were 1,400 miles out of their way and their course was unknown. Here again, know-



ledge of ocean currents might have aided search in the early stages.

The plots of the positions of the *Melanesian* wreckage are shown in the accompanying map*. It should be remembered that this was during the height of the season of the South-East Trades, and that during the North-west season it is very likely that there would be marked differences in the current picture†.

It is clear the current came from the north-east, assuming that the ship was lost somewhere in the vicinity of Sikaiana Atoll: dividing, it carried wreckage to the north-west and to the south-east along the coast of Malaita. At its southern point, it would seem that there

* Prepared from the plots as recorded on the chart by the Solomon Islands Police.

† On January 21st, 1959, the M.V. *Noula* made the trip Honiara-Savo Volcano in 2 hours 10 minutes, and the return some days later in 3 hours 15 minutes. The old-timer bosun commented how strange that during the NW season there should be such a strong current from the south-east, and during the SE season a current from the opposite direction.

was another distinct division, one current stream going westward leaving some wreckage on the eastern end of Guadalcanal, some on the north and some on the south coasts. A great quantity was carried in the stream south from Malaita, and dropped on the beaches of Ugi, and the north and eastern ends of San Cristoval. Parts of Malaita and San Cristoval coasts from where no wreckage was reported were well-populated, and it seems reasonable to suppose that wreckage was not found there, as all people were warned at the time.

A very large section of the ship's bridge upper-works was later found on the west coast of Ysabel, and other relatively small pieces were found on Lord Howe Atoll far to the north-west: indicating current trends in these areas, also.

Current research with numbered plastic enveloped drift cards would be relatively cheap and provide valuable data for future searches in the region. The work should be carried out as separate projects during seasons of the South-East Trades and North-West Monsoons because of almost certain current changes.

PROGRESS IN MAPPING TO 1958

By J. C. GROVER

Our primary aim is fundamental geological mapping. Nothing had been done before 1950, and it was not until 1954 that the work was properly under way, with a total of three geologists on strength. Substantial and excellent work was done by senior staff of the University of Sydney in 1951-52 (parts of Ysabel, San Jorge, W. Guadalcanal, Malaita), in 1956 (Ysabel, Central Guadalcanal), and 1957 (Choiseul). Subsequent research on all of these original surveys was done at Sydney, resulting in major contributions to the knowledge of these islands and at the same time freeing our modest organisation in the Solomons for other field work. Without this very generous support it would not have been possible to achieve anything like the results which have been produced.

In a year or so a preliminary map will be available covering the Protectorate: only the New Georgia Group, Ulawa, and some lesser islands remain unmapped; of course there are blank spaces here and there, for there is a limit to what can be done by so few in this very close and rough jungle country. Nevertheless the picture will be a clear enough regional one. It will then be possible to begin the serious work of detailed sheet mapping, from which greatest economic results are to be expected in due course.

During 1957 Mr. Pudsey-Dawson was in charge of the organisation, and the following areas were mapped:—
Choiseul 1 : 150,000 (by Coleman *et al.*).
South Malaita 1 : 150,000 (by P. A. Pudsey-Dawson, completed in 1958).

Ranongga
Gizo 1 : 50,000
Russell Islands 1 : 50,000

} by P. A. Pudsey-Dawson.

During 1957 and 1958 work proceeded steadily on the mapping of Eastern San Jorge in greater detail, and the ultrabasic rocks of the entire group to less detail—as part of the “BSIP Geological Research Project”.

Circumstances developed early in 1958 which made it convenient and advantageous to change the approach to the work (for this year only) and concentrate all personnel on areas of economic interest. Arrangements had been made (with C.D. & W. Funds) to equip H.M.S. *Cook* with a towed proton precession magnetometer, and F. Gray also brought a newly-devised portable magnetometer of the same kind which we were able to use in the field—in support of the Geological Research Project as well as elsewhere. With five geologists active and five others and a geophysicist from overseas organisations coming in to support or follow-up our previous work, quite a lot was done. The economic results of greatest importance are listed in Report No. 1.

The Geological Maps produced during 1958 include :
Hanesavo Island 1 : 10,560.

Hanesavo Manganese Deposit 1 in. to 50 ft.

- (a) Contoured map ;
- (b) Overlay showing grid and survey station numbers ;
- (c) Overlay showing magnetic survey results.

Eastern San Jorge 1 : 7,250

- (a) Laterite isopach map showing also areas of chrysotile concentrations ;
- (b) Overlay showing Laterite Test Pits and Boreholes ;
- (c) Map of area surveyed by proton magnetometer (1 : 7,250 only).
(Not yet available for publication.)

San Cristoval : Laterite areas east of Wainoni Bay
1 : 50,000.

(Not yet available for publication.)

Santa Ysabel : Nickeliferous Laterite areas near
Takata Bay 1 : 50,000.

(Not yet available for publication.)

Guadalcanal :

- (a) Laterite areas of Wanderer Bay 1 : 50,000 ;
- (b) Detailed Geological Map of Betilonga Area south to the Kavo Range 1 : 50,000 ;
- (c) Mineral-bearing areas in the Betilonga Basin
1 : 4,800, reduced to 1 : 9,600.

Apart from Geological mapping, maps of the Solomons are being prepared by the Department's Draughtsman from aerial photographs. These are being prepared in final form and printed by the Directorate of Overseas (Geodetic and Topographic) Surveys.

The following sheets are now available for sale at 2s.6d. (Australian) :—

Guadalcanal, 1 : 50,000, 14 sheets.

San Cristoval, 1 : 50,000, 8 sheets.

Florida, 1 : 40,000, 2 sheets.

In preparation in London :

Choiseul, 1 : 50,000.

In preparation in Honiara :

Santa Ysabel ; New Georgia Group ; Malaita ;
Santa Cruz ; Russell Islands.

This work is being done as the opportunity offers, and the priority depends on the areas where geological field work is being done at the time. In view of the inadequate charts the details of coral reefs on these maps are proving particularly useful for coastal navigation by saving valuable time in otherwise uncharted reef-bound waters.

Maps of limited areas have been drawn to large scale for use by the Marine Department and to illustrate reports by other departments. Sunprints are produced for private persons for a small fee.

ADMINISTRATION

(a) Finance

The Geological Survey activities continue to be financed entirely from C.D. & W. Funds. During 1957 and 1958 the expenditure under the various schemes has been as follows :—

(i) *Geological Survey C.D. & W.S. D2850*

	1957	1958
Capital	£86 12 0	£472 1 5
Personal Emoluments	5,291 5 8	8,266 11 2
Other Charges ..	3,542 18 10	7,106 4 3
	£8,920 16 6	£15,844 16 10

(ii) *P. J. Coleman's Geological Expedition 1957, C.D. & W.S. D3107.*

Grant £480 Stg. Expenditure £335.19s.6d.

Savings were made as it proved possible for the regular labour force of the Survey to be used on this Expedition owing to the absence of the Chief Geologist abroad and the new Geologist not having arrived.

(iii) *Marine Magnetometer Survey by H.M.S. Cook, 1958 C.D. & W.S. D3107 :*

Grant £1,150 Stg. Expenditure not finalised.

(This scheme was administered by the Secretary of State.)

(iv) *Seismological Station. C.D. & W.S. R972 :*

Grant £2,800 Stg. Expenditure Nil.

(This Grant was approved at the end of 1958.)

(b) Staff

(i) *Expatriates :*

Chief Geologist : J. C. Grover, B.E. (Min. & Met.) (Syd.), A.M.Aust.I.M.M., F.G.S., F.R.G.S.

Geologist : P. A. Pudsey-Dawson, B.Sc.(Reading), F.G.S., F.R.G.S.

Geologist : J. H. Hill, M.Sc.(Natal).

Secretary : Mrs. S. Evans (relieved during 1957 leave by Mrs. T. Handford).

Draughtsman : R. L. Warren.

B.S.I.P. Geological Research Project Geologists :

R. B. M. Thompson, M.A.(Cantab.), F.G.S.

(seconded from Geological Survey for three years).

J. H. Latter, B.A.(Cantab.).

J. C. GROVER was absent overseas from December 11th, 1956, until November 3rd, 1957, during which time he visited England, Ireland, Holland, Germany and Denmark, partly in connection with geological and proposed geophysical research concerning the Solomons. In March he addressed the Royal Geographical Society in London on "Some Geographical Aspects of the British Solomon Islands in the Western Pacific". In

June he flew to New York to take up a United Nations Fellowship, which enabled him to spend three months studying modern techniques of mining exploration and appraisal in Canada, a week in Hawaii on volcanoes and aspects of seismology, and a month in French New Caledonia studying the mining industry of that country. His stay there was interrupted by a four-day flying visit to the New Hebrides Condominium to advise on Mining Legislation in company with the French Chef du Service des Mines, Monsieur J. Gall. Subsequently he spent three weeks in the Condominium, during which he advised on mining and geological matters and visited Ambrym's two active volcanoes, and the islands of Pentecost, Malekula and Espiritu Santo. On return from leave in November, eight days were spent on San Jorge with J. H. Latter, seeing the areas mapped in detail during the year. During 1958 some 86 days were spent in the field—on Savo, Ndai, Ramos, North Malaita, Hanesavo, Eastern San Jorge and Ysabel, Eastern Choiseul, and the Betilonga area of Guadalcanal.

P. A. PUDSEY-DAWSON was acting Senior Geologist during 1957, and was occupied 130 days in the field working on Rennell Island, Choiseul, Malaita, Russell Islands, Guadalcanal, Savo, and the New Georgia Group. While in Honiara he completed a number of field and occasional reports and commenced the draft of this first Annual Record. He also instructed the staff and supervised the construction of new Melanesian staff quarters, which were finished and occupied in October. During 1958 he spent 110 days in the field on Savo, Hanesavo, the Koliula Valley of Southern Guadalcanal, South and East Malaita, and San Jorge. He departed on leave on December 2nd, and will not be returning : his resignation for personal reasons being sincerely regretted by all his colleagues.

R. B. M. THOMPSON returned from leave on January 5th, 1957. He had been given three years leave of absence from H.M. Overseas Service to take charge of the "BSIP Geological Research Project". He spent most of the year on Choiseul, San Jorge, Santa Ysabel and Guadalcanal, returning to Sydney on November 4th to continue his research, which will count towards a higher degree at the University of Sydney. He again returned on June 30th, 1958, continuing his field work until the end of the year, working on Choiseul, San Jorge, Santa Ysabel, Guadalcanal and San Cristoval.

J. H. HILL joined the Survey in July 1957 after graduating, having submitted his thesis for M.Sc. at Natal University. After a brief time in the office, and in the field assisting on Guadalcanal, he undertook the more detailed testing of the Bellona phosphate deposit, spending all told some 80 days in the field. In 1958 he spent 225 days in the field—on Savo, Hanesavo, San Jorge, and in the Betilonga area of the Guadalcanal Mountains.

J. H. LATTER joined R. B. M. Thompson in September 1957 and spent the next 16 months exploring the ultrabasic areas on Santa Ysabel and San Jorge, in particular sampling the nickeliferous laterites there and on Choiseul, Florida, Guadalcanal and San Cristoval.

MRS. S. EVANS went on leave in March 1957, returning to duty June 25th. The year 1958 marked the completion of her fifth year as part-time departmental secretary.

MRS. T. A. HANDFORD acted as part-time secretary during Mrs. Evans' absence on leave, March-June 1957.

R. L. WARREN completed the maps and diagrams needed for the publication of Memoir No. 2 early in 1957. He was on leave between February 11th and September 8th, 1958, during which period all mapping and draughting work was at a standstill, and it was not possible to finalise the 1957 Record for publication.

(ii) *Solomon Islanders :*

Geological Assistants :

ZEPHANIAH SALA, of New Georgia (eight years service).

JOHN PALM SUNDAY TEAITALA, of Ulawa (five years service).

CLEMENT MARAU, of Ulawa (five years service).

WILLIAM SAEMANE, of Guadalcanal (four years service).

Porters and Labourers :

About 20 as a rule, but up to 36 employed in 1958, the extras being financed by private funds.

The Geological Assistants have come from the better Mission Schools with a primary education background. They are trained to make compass traverses, collect specimens, make thin rock slices for microscopic exam-

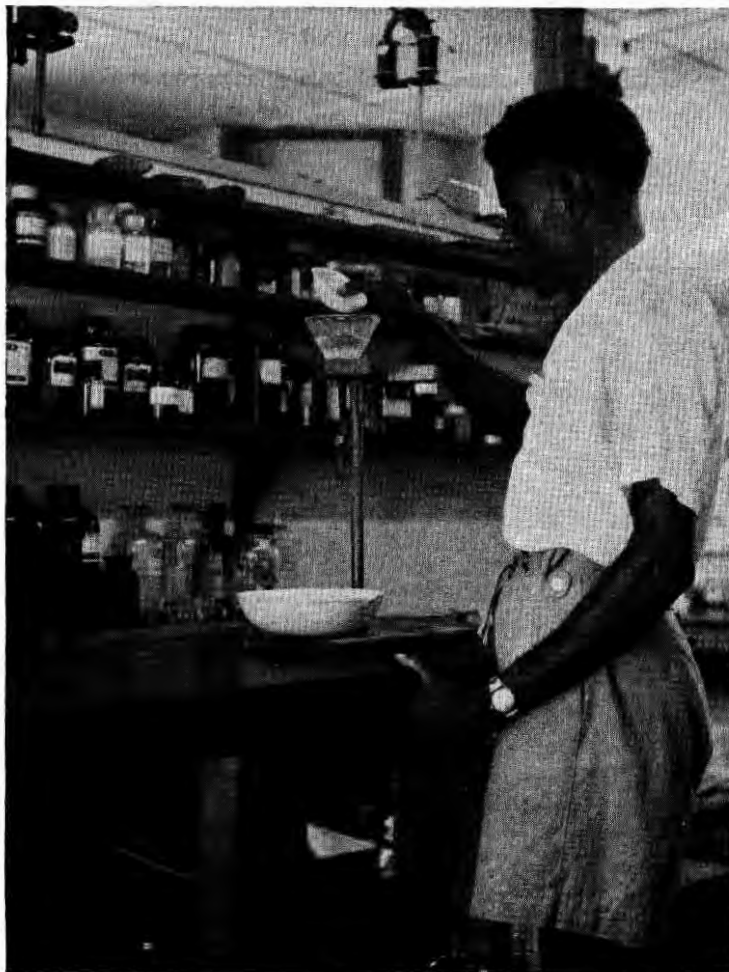


PLATE XXI

Geological Assistant, William Saemane, engaged in separation of heavy minerals from beach sand sample.



PLATE XXII

Geological Assistant, Zephania Sala, grinding rock sections.



PLATE XXIII

Staff quarters for Geological Assistants.

ination, and other simple laboratory work, as well as in the reduction of drawings by Eidograph, etc. John Teaitala was also trained as a touch typist during 1957 and has proved extremely helpful in this direction.

The Chimu-Borabora bushmen of the Guadalcanal mountains have preferred association with the Geological Survey since 1950, some having served almost continuously for eight years, many for lesser periods. In 1957-58 to assist with the Geological Research Project a number of Santa Ysabel bush and beach people were recruited, who also proved strong, willing and intelligent helpers.

Three new staff quarters (40 ft. x 20 ft., 20 ft. x 18 ft., 25 ft. x 18 ft.) were built by the Geological Survey staff between field trips—in semi-native style, on concrete pillars with sawn timber frame, corrugated iron roof, and woven bamboo walls.

(c) Visitors

DURING 1957

Dr. F. DIXEY, C.M.G., O.B.E., Director of the Overseas Geological Surveys, visited the Protectorate for a week at the end of June while on a tour of Geological Surveys in Far East Territories. He spent two days in Honiara discussing the policy and future of the Geological Survey Department. He then briefly visited Savo Volcano and later travelled by sea to Gizo in the Western Solomons, accompanied by Mr. Pudsey-Dawson.

Dr. Coleman from the Department of Geology and Geophysics, Sydney University, and Mr. Thompson met Dr. Dixey at Gizo. Both had been working on Choiseul. After a day of discussion Dr. Dixey flew out from the airstrip on Vella Lavella, accompanied by Dr. Coleman as far as Sydney.

Dr. P. J. COLEMAN was engaged in field work on Choiseul for six weeks in May and June, being financed by a grant from C.D. & W. Funds. For part of the time he was accompanied by Mr. Thompson, whose main interest was in the ultrabasic rocks of the east end of the island.

Dr. N. H. FISHER, Chief Geologist of the Australian Bureau of Mineral Resources in Canberra, accompanied by Mr. E. H. Woods (Assistant Secretary of Industry and Commerce for the Department of Territories in Canberra) visited the Protectorate for a week in September. They had preliminary talks with Government concerning the proposed Phosphate Expedition to the Protectorate in 1958, part of a scheme by the Australian and New Zealand Governments planned to explore the small coral islands in the South West Pacific area.

Dr. Fisher again visited Savo Volcano crater; he advised on positions to obtain critical temperatures, and noted that there had been no change of volcanic activity since his previous visit in August 1956. Later he accompanied Mr. Pudsey-Dawson to Visale in search of a good site for a seismological station, proposed for both regional studies and to keep a watch on the now quiescent volcano. Subsequently it was decided that Honiara seemed to offer the best available site. On Dr. Fisher's recommendations seismographs and ancillary equipment

are now being purchased and will be installed during 1959.

Mr. P. ROGERS, C.M.G., Assistant Under-Secretary of State in the Colonial Office, visited the Department for an afternoon on April 5th during his brief stay in the Protectorate.

MISCELLANEOUS. During the year parties of Melanesian clerks and headmen have visited the Department, have seen various demonstrations, and have had the work of the Survey explained to them. These outside contacts with Melanesians have been well worth while: a few years ago there was open hostility, but now the people have begun to realise the implications of the work, and co-operation has become the rule.

DURING 1958

January

Miss MOLLIE BOYLE, World Health Organisation Yaws Campaign Secretary.

February

Dr. ROBERT DE VLETTER, Canada.

March

Mr. F. GRAY, Imperial College of Science and Technology, London.

April

Lieut.-Commander J. PATON and Lieutenant B. DIXON, of H.M.S. *Cook*.

Monsieur BERNARD HEBERT, Mr. R. HUTCHINSON, and 11 MELANESIAN HEADMEN from the New Hebrides Condominium.

Mr. W. WHITE, Mr. O. WARIN, Mr. C. JENSEN, Geologists from the Australian B.M.R., Canberra.

Miss MARGARET BARR, Kooyong, Victoria.

Professor SAM ELBERT, University of Hawaii.

May

Dr. CHARLES PHIPPS, Department of Geology and Geophysics, University of Sydney.

Messieurs ROTCHI, BERNARD and LE GAL, Scientists from M.V. *Orsom III*, Oceanographic Laboratory Vessel of the Institut Francais d'Océanie.

Sir JOHN GUTCH, K.C.M.G., O.B.E., High Commissioner for the Western Pacific, and Lady GUTCH.

V. J. ANDERSEN, Esq., M.B.E., Acting Chief Secretary for the Western Pacific.

August

Monsieur ROLAND PRIAM, Mines Officer, New Hebrides Condominium.

September

M. D. I. GASS, Esq., Chief Secretary to the Western Pacific High Commission.

Professor DAVIDSON, Australian National University, Canberra.

Mr. J. F. ISAAC and Mr. S. G. PUTNAM, Education Officers, newly arrived from England.

Dr. and Mrs. BILL DAVENPORT, University of Yale, U.S.A., en route to Santa Cruz for 18 months ethnographic study (T.R.I.P. Programme).

Dr. TORBEN MONBERG, Ethnographer, Copenhagen, Denmark, and Mr. STEN WILLER ANDERSEN, Civil Engineer, Copenhagen, en route to Rennell Island for four months study of pre-Christian religions.

November

Mr. and Mrs. H. SCHEFFLER, Ethnographer, University of Chicago, U.S.A., en route to Choiseul for 18 months ethnographic study (T.R.I.P. Programme).

Mr. D. J. DERX, Pacific Department, Colonial Office.

broken down. Rock specimens, long stored elsewhere under unsatisfactory (periodically wet) conditions, have weathered and many have become unrecognisable. Aerial photographs, optical and other instruments are now suffering. New facilities are planned, and it is hoped that these will be constructed in 1959.

(e) Transport by Sea and Land

M.V. *Noula* has been in constant use during all of 1958, supplemented at times by larger vessels when needed. We are grateful for the consideration we have enjoyed from the Superintendent of Marine, which has enabled us to extend considerably the scope of our activities.

We have also experienced periods of anxiety, such as



PLATE XXIV

Converted 60 ft. x 20 ft. underground bomb-dump, now used as stores and drawing office, in foreground, with the 30 ft. x 30 ft. office and laboratory building beyond.

(d) Office and Laboratory Facilities

The facilities have not been sufficient to handle the increased output of four field geologists, and chaotic conditions have resulted at times. The 60 ft. x 20 ft. war-time underground building, serving as a drawing office and store, has deteriorated, and is no longer water-proof; the small air-conditioning and dehumidifying unit has therefore proved inadequate, and has now

on the occasion when big seas stove in the for'ard deck and filled the ship with water during a dark, stormy night; fortunately the engines and pumps kept working and soon pumped it out again. Failure of the fuel filter in heavy seas has caused the engines to stop many times: when this happens in proximity to great seas thundering onto nearby reefs it can be rather alarming—particularly with up to 24 people on board and dinghy space only for a few.

This 37-ft. ship is far too small to permit laboratory work on board, and is far too dangerous to use as we have to : but so far good luck has been with us.

There has been considerable wear and tear on the Land Rover pick-up and trailer unit, which has been used for

supplying the Mount Austen roadhead to Betilonga Area. The war-time roads are bad, but use has to be made of them as far as possible as the man-carrying distance is at the limit for a day, and through very trying country.

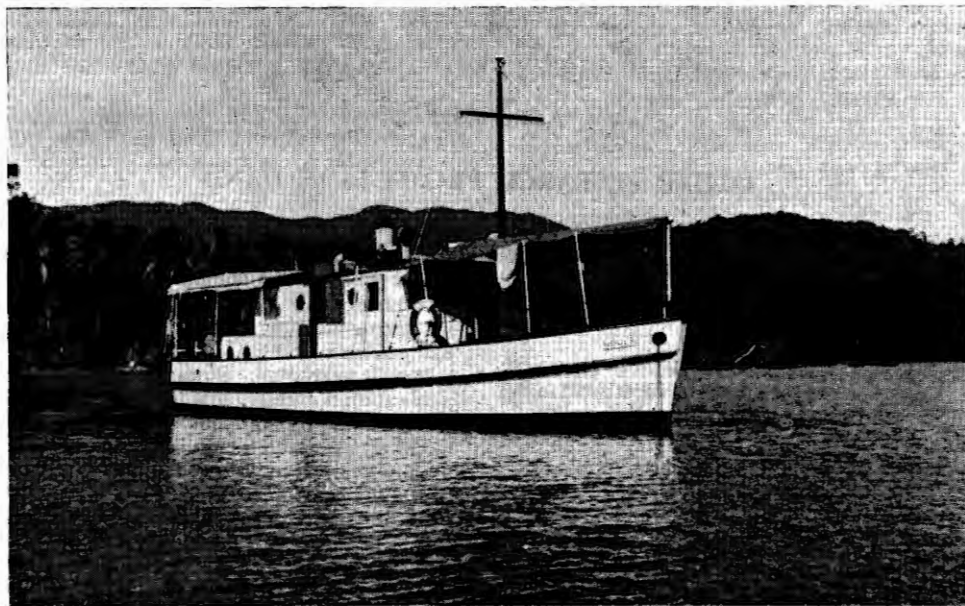


PLATE XXV

The 37-ft. M.V. *Noola*, used by the Geological Survey Department.

APPENDIX A

LIST OF UNPUBLISHED REPORTS, 1957-58

- PUDSEY-DAWSON, P. A. Brief Quarterly Reports 1957 (4).
—— Brief Annual Report to July 1957 for the Director of Overseas Geological Surveys.
- GROVER, J. C. Some Implications of the Joint Mining Regulation of 1957 in the New Hebrides Condominium.
—— A Proposal for a Geological Survey Service in the New Hebrides Condominium.
—— Exploration, Appraisal and Development of Mineral Resources: A Final Report on United Nations Fellowship Studies in Canada, Hawaii, and New Caledonia. 85 pp. foolscap.
- Triennial Report on Geology and Mining in the Solomons: For incorporation in Report to United Nations.
—— Brief Quarterly Reports, 1958 (4).
—— Brief Annual Report to July 1958 for the Director of Overseas Geological Surveys.
—— Proposal for Aerogeophysical Surveys in the British Solomon Islands.
—— One Year After—A Follow-up Report on the United Nations Fellowship Studies, 1957.

APPENDIX B

OTHER RESEARCH PROJECTS IN HAND

Important research projects in hand which are not dealt with in this report are as follows:

1. Ultrabasic Research Project

Begun in January 1957, field work was completed in December 1958. Mr. R. B. M. Thompson has been responsible, assisted in the field during the final 16 months by Mr. J. H. Latter.

Emplacements of ultrabasic rocks over 400 miles of the Solomon Islands have been the subject of study.

Laterite cappings have been extensively bored and pitted and sampled; and several hundreds of assays have been made of their nickel and cobalt (and sometimes copper and chromite) content. The islands of Choiseul, Santa Ysabel, San Jorge, Florida, Guadalcanal and San Cristoval have received attention, and the results have indicated certain areas of possible interest*.

Nine areas* of San Jorge have been delineated as showing up to three per cent and occasionally greater concentrations over restricted areas of rather short staple silky chrysotile fibre. These are to receive further specialised attention in the future.

The project has been entirely financed by two overseas companies who have joined to form the "British Solomon Islands Protectorate Geological Research Project"; two geologists and the necessary labour force have been put in the field and have been treated virtually as part of the Geological Survey in administrative and transport matters. This very substantial financial and technical contribution has more than doubled the effectiveness of the Geological Survey Department during these two years; at no extra cost to the Protectorate Government. The arrangement has been very satisfactory from this point of view, and apparently also from the point of view of the Research Project.

Mr. R. B. M. Thompson is to spend 1959 in research on the results of his field work at the Department of Geology and Geophysics at the University of Sydney. His final thesis should be a major contribution to the knowledge of ultrabasic rocks, and may well have economic implications.

2. Marine Magnetometer Survey by H.M.S. Cook

As mentioned elsewhere in this volume, C.D. & W. funds were made available to fly Mr. Gray from the Imperial College of Science

and Technology to New Zealand, where he equipped H.M.S. *Cook* with a towed "fish" containing a proton precession magnetometer of his own design and construction. About 10,000 miles of magnetometric measurements were made possible, simultaneously with bathymetric soundings in the region. Some of the results have been extremely interesting. Research is now being done in London, and publication is expected at a later date.

Mr. Gray also brought with him a lightweight portable field model of a prototype Proton Precession Magnetometer which was used in field tests over mineral deposits for the first time. Every effort was made to utilise this instrument to the full on different types of country during the couple of weeks that it was available. It was simple to use, could be handled by islander staff, gave no electronic trouble whatever, and suffered only from simple mechanical defects due to improvisations that were necessary to complete it in time for the Solomons trip. Notes on its performance are given in Report No. 17 and it is expected that Mr. Gray will be writing later at greater length on this subject as well.

3. Economic Minerals of the Solomon Islands

Dr. R. L. Stanton, of the University of New England, Armidale, New South Wales, is working on a collection of minerals from the Solomons at the present time. Dr. Stanton has recently presented for publication a report on the Geology of the entire island of Santa Ysabel.

4. Palaeontological Studies

Dr. P. J. Coleman, of the University of Sydney, two of whose reports (Guadalcanal and Choiseul) are included in this volume, is engaged in palaeontological studies which he proposes to publish in due course. These results will be of considerable importance to the understanding of the stratigraphy of the region.

5. "Operation Syngenesi"

Preliminary studies have begun, and moves have been made, to obtain finance for specialist investigation of certain favourable areas in the Solomons. It is expected that two years of preliminary work will be necessary before the possibilities of this undertaking can be properly assessed, and plans for 1961 will depend entirely on these preliminary studies. The prime mover in this project is Dr. R. L. Stanton, whose recent publications on associated subjects are of such interest to economic geologists.

* Now held under Prospecting Licenses.

APPENDIX C

A BIBLIOGRAPHY OF GEOLOGICAL AND MINING REFERENCES TO B.S.I.P.

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APPENDIX D

REPORT ON MINERALOGICAL EXAMINATION OF HEAVY SAND AND GRAVEL CONCENTRATES FROM MALAITA

By Miss B. B. Fox, B.Sc.

Overseas Geological Surveys (Mineral Resources Division)

(Ref. No. M.6454/44)

The samples were submitted by the Chief Geologist, Geological Department, British Solomon Islands, and are listed in his letter of 14th February, 1959.

Sample No. 81, Kwaiafa River

The sample is a coarse sand (one-third has a grain size greater than 1 mm.). It is completely non-radioactive.

26 gm. of material were crushed to -20 B.S.S. and then split by sink/float separations using bromoform and methylene iodide. The resulting fractions were further sub-divided using the electromagnetic separator.

	Per cent (approx.)
5.6 gm. low S.G. (quartz, foraminifera, etc.)	22
7.0 gm. Pyroxene	27
4.8 gm. Ilmenite (?)	18½
4.0 gm. Garnet	15½
2.1 gm. Magnetite	8
2.0 gm. Forsterite	7½
0.4 gm. Spinel	1½
Trace Brookite	—

Removal of calcite from the low S.G. fraction (with dilute HCl) left a residue of only 0.8 gm., which consisted of quartz and crypto-crystalline silica—no sign of beryl.

The fraction tentatively identified as *ilmenite* consists of a moderately magnetic, opaque mineral which sinks in methylene iodide and has a black streak.

The *garnet* consists of sub-angular fragments with occasional grains 4 to 5 mm. in diameter, but the average grain size is of the order of 1 mm. It is a light orange/red colour and has a variable R.I. (close to 1.74), indicating the magnesian end of the pyrope-almandine range.

The *forsterite* (R.I.s above and below 1.68, high birefringence, biaxial +ve with 2V close to 90, very hard (sinks slowly in methylene iodide), is particularly colourless and shows no sign of alteration. The identification has been confirmed by an X-ray powder photograph.

Spinel occurs in small octahedral grains. In very thin slivers it is brown and has an R.I. of 1.90.

Brookite occurs in very small, euhedral, dark red grains showing a very high refractive index, strong dispersion, anomalous birefringence colours and weak pleochroism.

The *pyroxene* is largely *augite*—dark green grains which are practically colourless in the crush ($\gamma = 1.70$ biaxial +ve, moderate 2V, $Z \wedge C 38^\circ$). There is, however, in addition a light green clino-pyroxene (pleochroic in blue green and yellow, biaxial +ve with a large 2V and $\gamma = 1.680$), i.e. *diopside* and a markedly pleochroic orthopyroxene ($\gamma = 1.685$, biaxial -ve with $Z = C$) i.e. *hypersthene*.

Careful examination of all fractions failed to reveal topaz, diamond or any other gem minerals.

Briefer accounts of the other five samples are given below. None contain significant amounts of garnet. All were examined carefully for radioactive minerals, diamond, beryl, topaz or other gem minerals without success. The +30 fraction has been removed in each case since this consists largely of fine-grained rock fragments.

Sample No. 74, Kwaibeta river mouth

The sample is a fine-grained black sand (nothing retained on 30 B.S.S.).

16.8 gm. of material were split by sink/float separation and by magnetic methods to give the following fractions:—

- 3.19 gm. Magnetite (removed by hand magnet).
- 84 gm. Quartz, plagioclase, volcanic glass (bromoform float).
- 2.12 gm. Pyroxene + volcanic glass (M.I. float).
- 793 gm. Pyroxene + ilmenite (M.I. sink strongly magnetic).
- 9.74 gm. Pyroxene (remainder of M.I. sink).

Pyroxene constitutes about 70 per cent of the total sample and *magnetite* 20 per cent.

The *glass* has S.G. very close to bromoform and R.I. 1.16 (i.e. *basaltic glass*). *Ilmenite* forms less than 2 per cent of the total sample. There is no sign of garnet, forsterite, brookite or gem minerals.

Sample No. 75, From black sand beach, mouth of Kwaibeta River

The sample is a fine black sand (nothing retained on 30 B.S.S.).

26.8 gm. of material were split by sink/float separations and magnetic methods to give the following fractions:—

	Per cent (approx.)
4.98 gm. Magnetite (removed by hand magnet)	19
1.29 gm. Quartz, plagioclase, etc. (bromoform floats)	4
2.90 gm. Pyroxene (M.I. floats)	11
17.63 gm. Pyroxene + ilmenite + garnet (M.I. sinks)	66

Ilmenite in the methylene iodide sinks forms about 5 per cent of the total sample. *Garnet* is present as a trace only.

Plagioclase is labradorite range.

Pyroxene is augite.

There is no sign of forsterite, brookite or gem minerals.

Sample No. 76A, From A'ari River

This coarse sand (38 per cent with grain size greater than 30 B.S.S.) contains no garnet.

15.93 gm. of sample were treated, the —30 B.S.S. fraction being split by sink/float separations and magnetic methods.

	Per cent (approx.)
(6.06 gm. + 30 B.S.S.)	
11 gm. removed by hand magnet—magnetite ..	1
2.14 gm. Calcite, quartz, etc. (bromoform float)	22
3.81 gm. Methylene iodide floats) Pyroxene+rock	77
3.80 gm. Methylene iodide sinks) fragments.	

Ilmenite is present as a trace only.

Rock fragments composed largely of pyroxene are an important constituent of the sand.

The bromoform float contains a considerable amount of *pink cryptocrystalline silica* which may have been mistaken for garnet.

There is no sign of garnet, forsterite, brookite or gem minerals.

Sample No. 82, From Auluta River

The sample is a coarse sand (19 per cent with grain size greater than 30 B.S.S.).

16.33 gm. of sample were separated by sieving (30 B.S.S.) sink/float and electromagnetic methods.

	Per cent (approx.)
(3.17 gm. + 30 B.S.S.)	
5.23 gm. removed by hand magnet—magnetite..	40
1.64 gm. Quartz, foraminifera, etc. (bromoform float)	12½
3.56 gm. Methylene iodide floats (Pyroxene and amphibole)	27½
2.64 gm. Methylene iodide sinks (Pyroxene, ilmenite+)	20

The *magnetite* occurs in octahedral grains, opaque, strongly magnetic, grey and metallic in reflected light with a black streak.

Ilmenite, which can be readily separated from the methylene iodide sinks on the electromagnetic separator at a low current strength, consists of grey metallic, platy grains, opaque in crush and with a black streak. It constitutes about 5 per cent of the —30 B.S.S. sample.